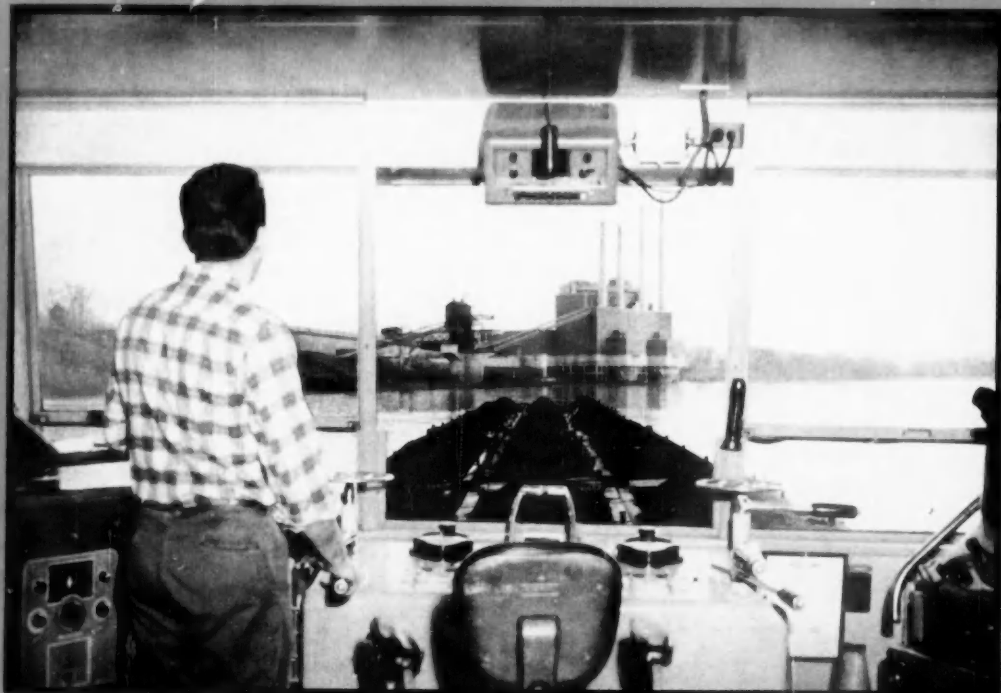
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August 1958



Typical view from operator's window of a coal barge approaching the Walter Beckjord Station, Cincinnati Gas & Electric Co.

A Growth Member of the

"500 CLUB"

In its July issue, FORTUNE magazine published its "Directory of the 500 Largest Industrial Corporations." This well-known directory, now an annual feature, lists companies according to sales volume for the preceding year. Combustion's progress continues at a healthy rate, with rankings for the past three years as follows:

256th in 1955 . . . 232nd in 1956 . . . 148th in 1957!

This growth reflects the ever increasing acceptance of C-E Boilers by leading utilities and industrials, both at home and abroad. And we look forward to still another elevation in rank next year in the world's most exclusive business club — the "Top 500" . . . for Combustion's 1958 billings promise to be the highest in the company's history.

C-172

C-E

COMBUSTION ENGINEERING

Combustion Engineering Building

200 Madison Avenue, New York 16, N. Y.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 30 **No. 2**

August 1958

Feature Articles

Editorials

Departments

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Associate Editor

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BPA

Printed in U. S. A.

THE BAYER CO.

MANUFACTURERS OF BAYER SOOT BLOWERS

For Highest First and Final Value

. . . BUY BAYER!

BAYER

Balanced Valve

SOOT CLEANER

Bayer's single-chain design compels perfect in-step operation of valve and element. Operation is positive, definite, assuring a full flow of steam for efficient cleaning.

When the operator pulls chain, the cam-actuated, quick-action balanced valve is opened. By continued pulling of the chain, worm drive slowly rotates element over cleaning arc. When element reaches end of cleaning arc, valve automatically closes.

Minimum steam consumption low maintenance. Every detail is engineered, built for long life, efficient performance at high temperatures and high pressures.

More than 35,000 boilers are Bayer equipped. More than 50 years' successful, specialized experience assures you investment economies in Bayer equipment.

QUALIFIED LOCAL ENGINEERING SERVICE—Your Bayer representative is an experienced engineer, well qualified to take care of any service needs in connection with Bayer Soot Cleaners. He is available when you call upon him and will gladly render any service required.

All These Mechanical and Operating Advantages are available in

The BAYER *Balanced Valve* SOOT CLEANER

1. **Sound engineering, workmanship, and materials of the best.**
2. **An organization of over 50 years' experience, capable and willing to render service at all times.**

SINGLE CHAIN: Valve and element controlled by a single chain.

VALVE BODY: Rugged construction, built to last. Short and ample steam passage giving very small pressure drop.

ORIFICE PLATE VALVE: For high pressure service, each head may be controlled by an orifice plate valve through which pressure is adjusted for each individual element.

STUFFING BOX: Due to maintenance of perfect alignment on swivel tube, packing needs little attention. Stuffing box is in full view, readily accessible.

AIR SEAL: Has machined surface on wall sleeve and spring-held floating seal to prevent air in-leakage.

HEAD BEARINGS: There are two main bearings, an outboard and an inboard bearing for the swivel tube to maintain alignment.

THRUST BEARING: Ring type thrust bearing takes the load.

VACUUM BREAKERS: Two vacuum breaker air valves, or one valve and a signal whistle above each valve, to prevent suction of boiler gases into valve and piping.

ELEMENT OPERATION: With the Bayer element operation, balanced valve is opened just as element rotates, giving FULL pressure over entire cleaning arc. Full steam pressure insures thorough cleaning. Balanced valve saves wear of valve parts. With any type of poppet valve, this is important. . . ask any operator.

BLOWING ARC: Valve cams automatically regulate cleaning arc.

REDUCTION GEARS: 24 to 1 gear ratio gives slow rotation for good cleaning.

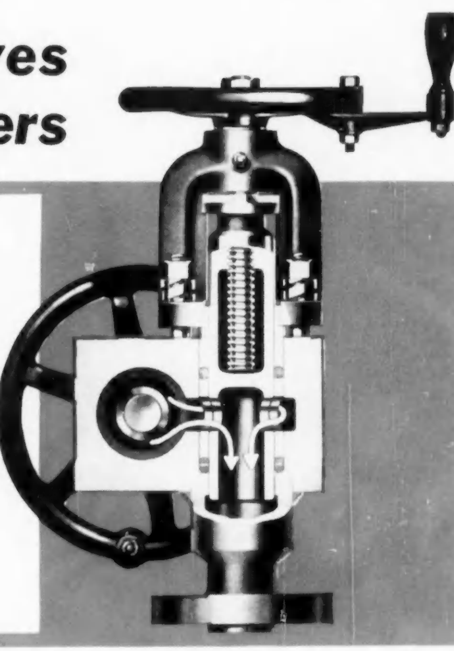
FLANGED PIPE CONNECTION: Operating head is connected to supply pipe by flanges and through bolts, or high tensile studs and nuts.

THE BAYER CO.

St. Louis, Mo.

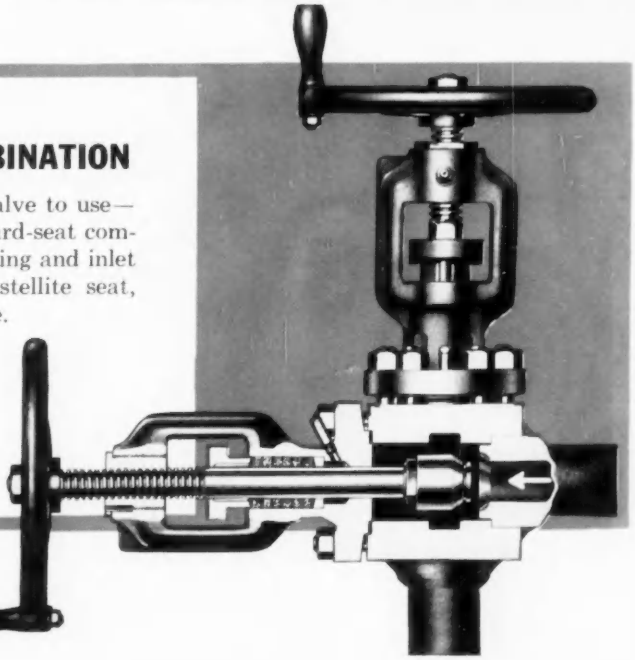
UNIT TANDEM

rugged blow-off valves for high pressure boilers



HARD-SEAT—SEATLESS COMBINATION

■ For boilers up to 1500 psi, this Yarway Unit Tandem Blow-Off Valve offers the maximum in dependable service. A one-piece forged steel block serves as the common body for the Yarway Stellite Hard-seat blowing valve and the Yarway Seatless sealing valve. All interconnecting flanges, bolts and gaskets are eliminated. The Unit Tandem at right is sectioned through Seatless Valve to show balanced sliding plunger in open position and free flow.



HARD-SEAT—HARD-SEAT COMBINATION

■ For boilers to 2500 psi, this is the valve to use—Yarway's Unit Tandem Hard-seat—Hard-seat combination. Disc has welded-in stellite facing and inlet nozzle has integral welded-in heavy stellite seat, providing smooth, hard-wearing surface.

OVER 4 OUT OF 5
HIGH PRESSURE PLANTS
USE YARWAY BLOW-OFF VALVES

Write for Yarway Catalog B-434

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY BLOW-OFF VALVES

Republic ELECTRUNITE

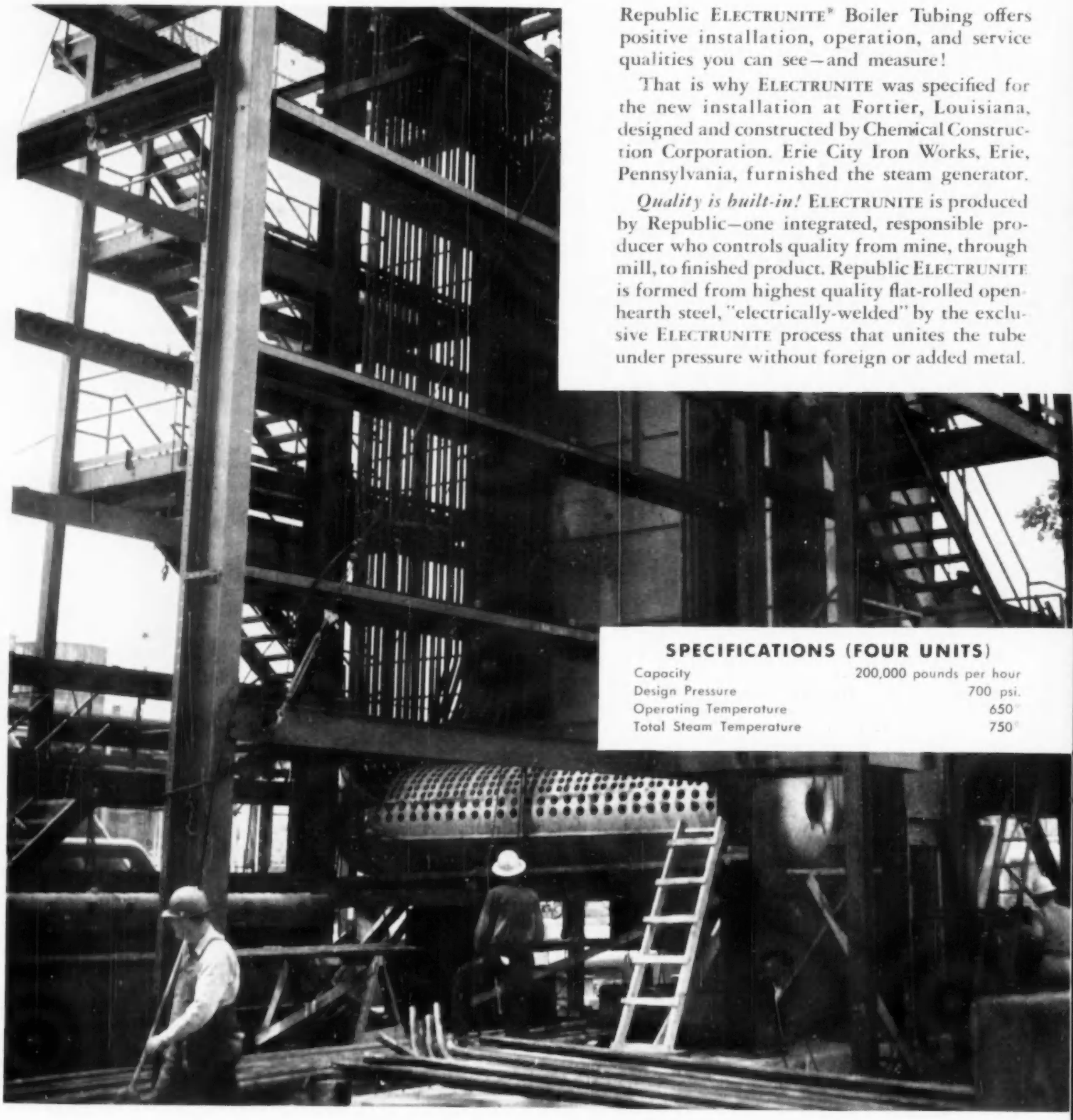
offers QUALITY YOU CAN

ELECTRUNITE...installed at CHEMICO designed plant

Republic ELECTRUNITE® Boiler Tubing offers positive installation, operation, and service qualities you can see—and measure!

That is why ELECTRUNITE was specified for the new installation at Fortier, Louisiana, designed and constructed by Chemical Construction Corporation. Erie City Iron Works, Erie, Pennsylvania, furnished the steam generator.

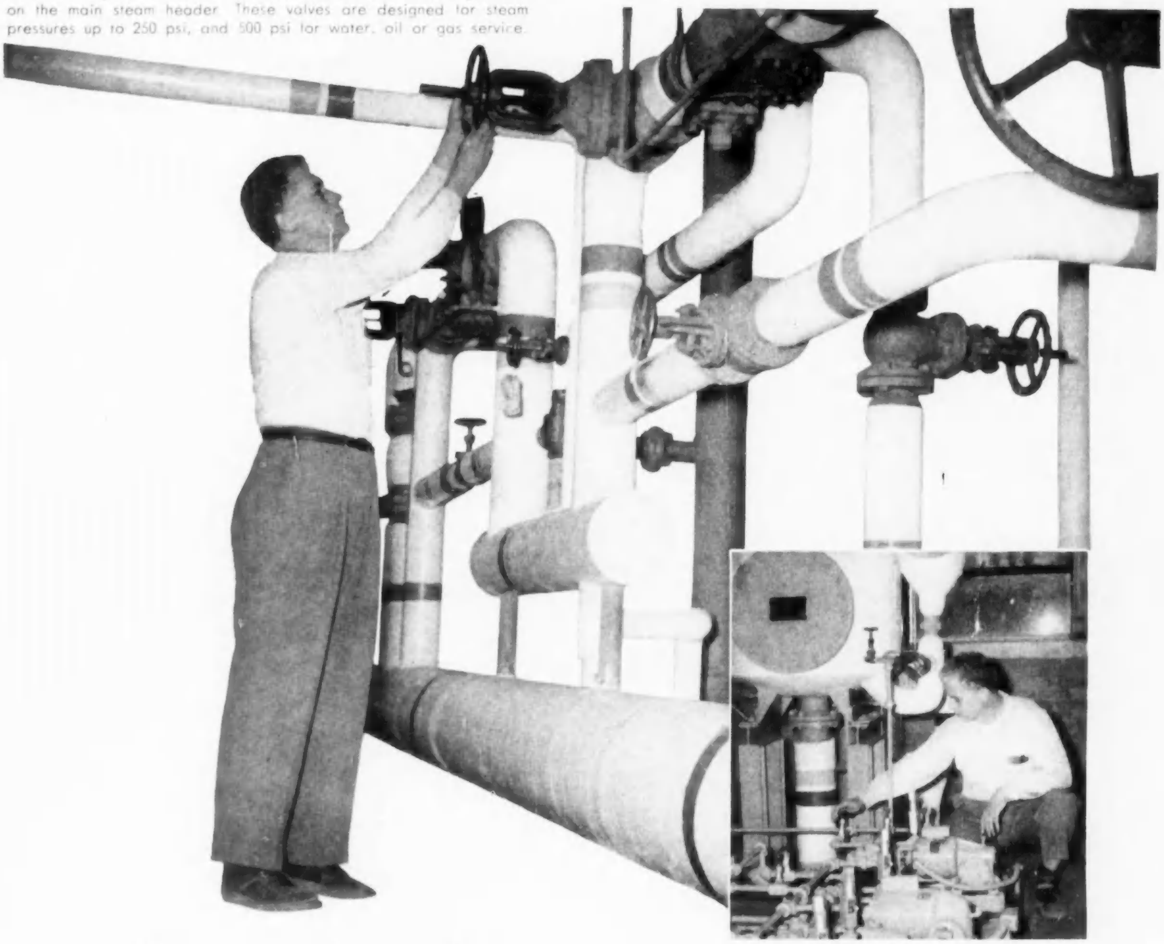
Quality is built-in! ELECTRUNITE is produced by Republic—one integrated, responsible producer who controls quality from mine, through mill, to finished product. Republic ELECTRUNITE is formed from highest quality flat-rolled open hearth steel, "electrically-welded" by the exclusive ELECTRUNITE process that unites the tube under pressure without foreign or added metal.



SPECIFICATIONS (FOUR UNITS)

Capacity	200,000 pounds per hour
Design Pressure	700 psi.
Operating Temperature	650°
Total Steam Temperature	750°

The Chief Engineer closes an 8-inch Walworth Iron Body Wedge Valve on the main steam header. These valves are designed for steam pressures up to 250 psi, and 500 psi for water, oil or gas service.



Chief Engineer Bruce W. Martin checks Walworth Bar Stock Valves in chemical feed pump lines to boiler and feed water. These carbon steel valves are built for ratings up to 3000 psi. Stainless steel bar stock valves are also available for very severe service.

"from big gates to little globes"...

The power plant at the Michigan School for the Deaf has an operating capacity of 25,000 lbs. per hour generated by three 200 hp and one 60 hp oil-fired boilers. Built four years ago, the plant is now the responsibility of Chief Engineer Bruce W. Martin who says: "This plant was designed and constructed for efficient operation, and a lot of that efficiency depends on the valves. From big gates to little globes installed here, we use a wide variety of Walworth Valves. They give us the dependable, trouble-free service we want and expect. I would recommend them to anybody for similar service."

Walworth's complete lines of valves are built to provide long range service and savings. There's a Walworth Valve in a type, size, and material to serve you . . . Gate, Globe, Angle, Check, and Lubricated Plug Valves in a variety of pressure ratings. The next time you need valves or have a problem concerning flow control, call your Walworth Distributor, or, write Walworth direct.

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750 THIRD AVENUE, NEW YORK 17, N. Y.

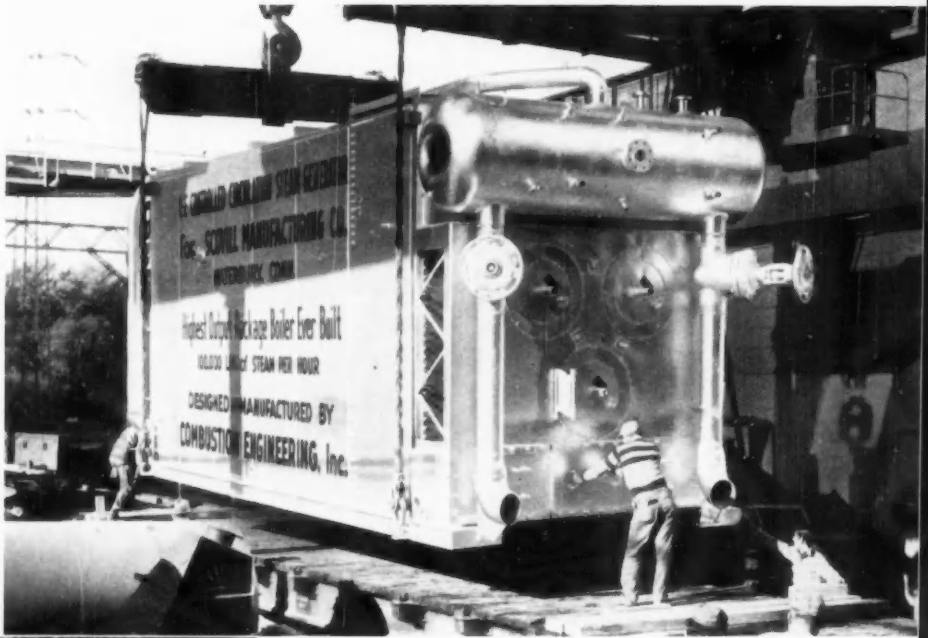
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

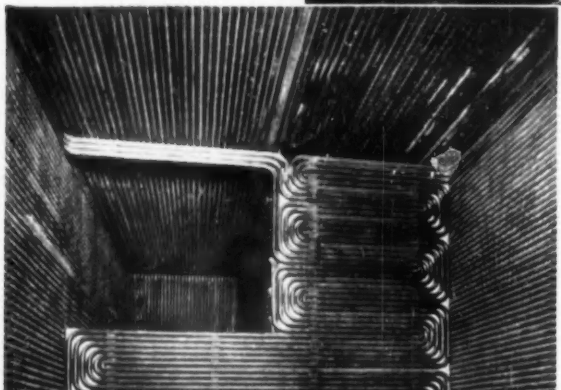
WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

Announcing

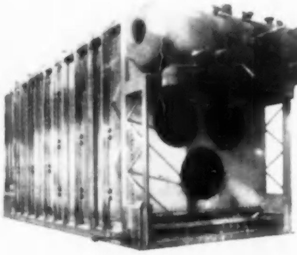
THE C-E CONTROLLED

Another Combustion first in the boiler field — the type PCC package unit, utilizing controlled circulation. This one, being loaded at our St. Louis shops for delivery to Scovill Manufacturing Co., is the world's highest output package boiler, having a design capacity of 100,000 lb. of steam per hr. This picture illustrates the ease with which this new, high performance design can be readied for shipment. Its size permits transfer from railway siding to destination by truck.

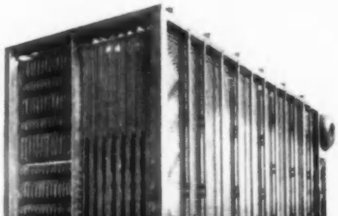




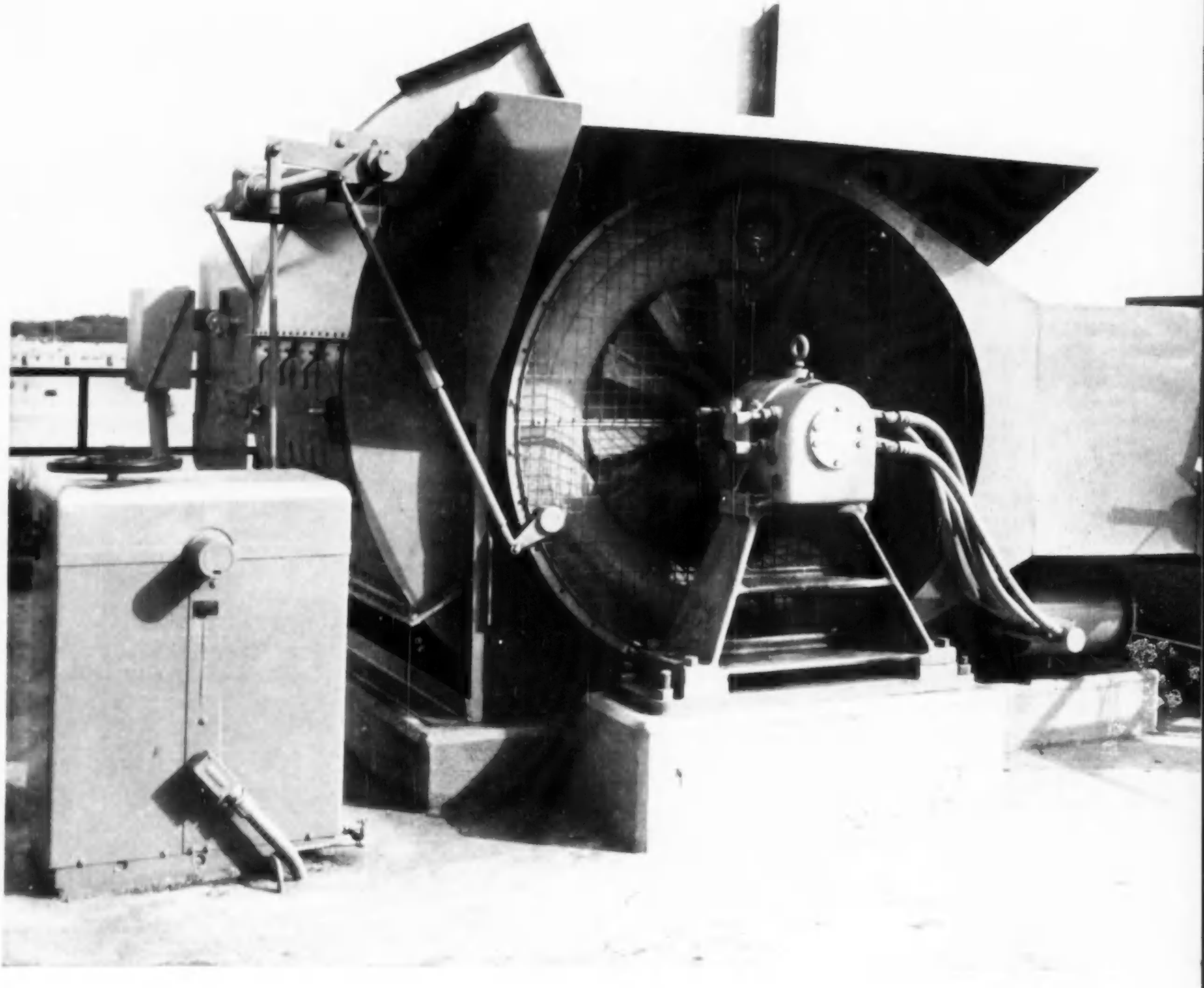
Tubing arrangement—looking toward rear through burner opening.

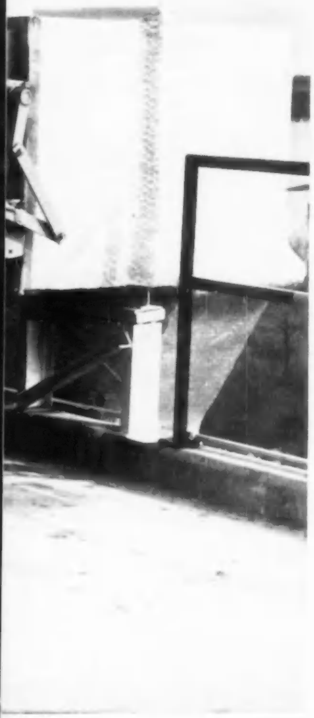


Fabrication view of drum end of 100,000 lb. per hr. type PCC boiler. Three circular openings accommodate burners. Integral structure requires no outside support for boiler.



Rear view of type PCC points up superheater arrangement and complete waterwall construction of this boiler.





HERE'S MECHANICAL DRAFT PERFORMANCE OUT IN THE OPEN

Here is a typical "Buffalo" Forced Draft Fan engineered for outdoor service. Features "A" apply primarily to outdoor installations. Features "B" apply to Buffalo Forced Draft Fans in general.

FEATURES "A": Note first the air cooled bearing mounted on rigid cast iron pedestals and soleplates. Pressure from fan discharge provides air for cooling. Air passes through automotive type filter before entering oversize cooling passages and specially designed bearing sleeves. Use of air cooled bearings removes danger of freezing.

SHIELD OVER INLET helps keep rain and snow from fan air stream. SCREEN keeps loose objects from entering.

RECIRCULATING AIR DUCT brings preheated air to fan inlet for mixing with outside air to prevent corrosion in air heater at low boiler loads.

PROPORTIONING DAMPERS in this duct regulate and mix the air flow.

FEATURES "B": HEAVY DUTY VARIABLE INLET VANES deeply positioned in inlet for maximum horsepower reduction at reduced loads. Vanes are cantilevered, nothing obstructs inlet air flow. One lever accurately controls dampered combustion.

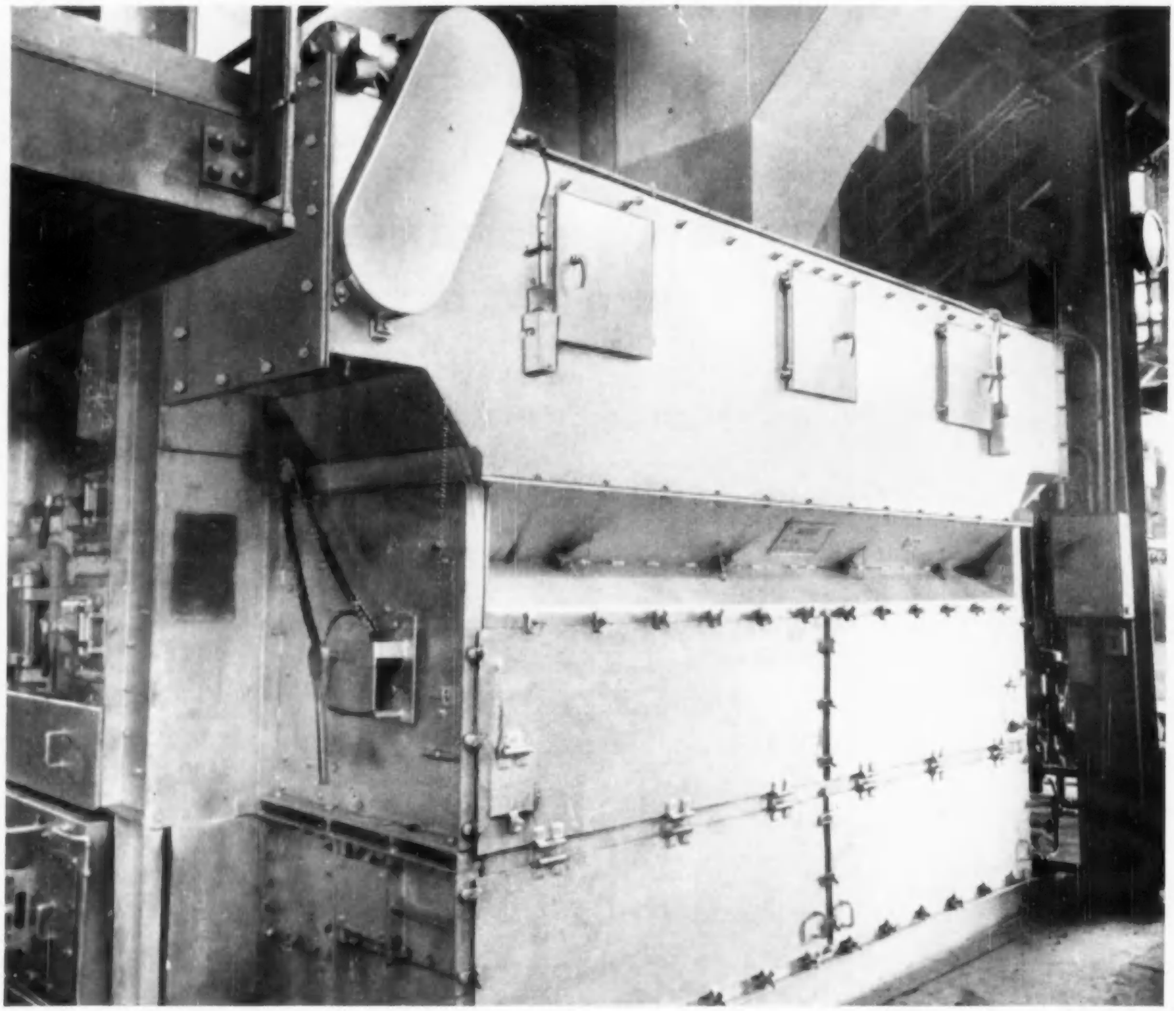
INSPECTION DOOR has quick opening latches for easy access to fan housing.

OVERALL "Q" FACTOR CONSTRUCTION is strictly heavy duty. Steel plate and rigid bracing contribute to maintenance-free fan life.

BUFFALO, NEW YORK
Buffalo, N. Y.
Co., Ltd., Kitchener, Ont.

"Buffalo"

EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING



City of St. Marys, Ohio, Municipal Light and Power Plant
Beiswenger, Hoch and Associates, Consulting Engineers

ANNOUNCING

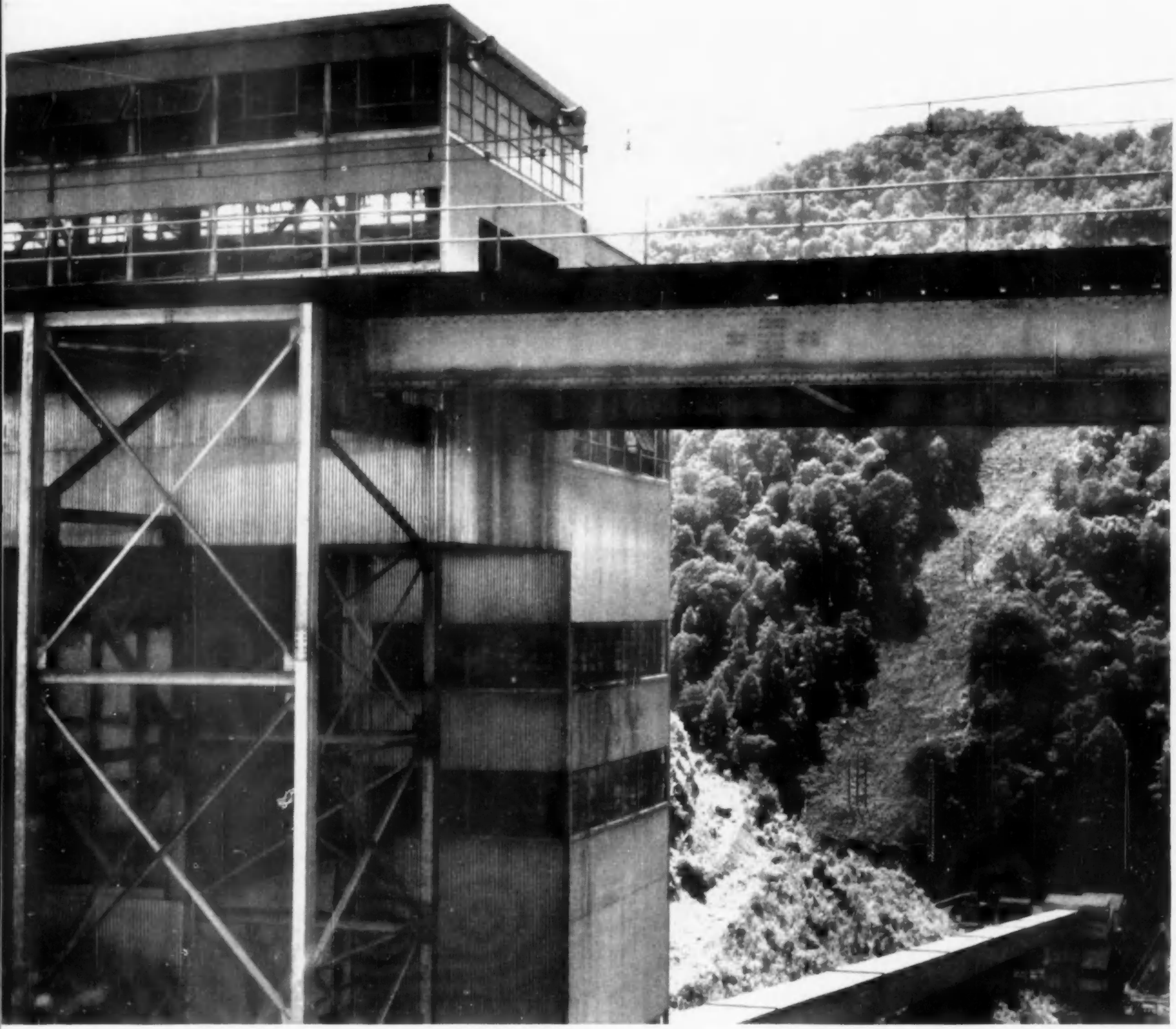
The Stock Equipment Company Non-Segregating Layer Loader is a new and positive way to insure even stoker fires. This mechanical distributor mixes separated fine and coarse coal, removing the bad effects of bunker segregation. The mixing action of the layer loader also makes tempering more uniform.

The S-E-Co. Non-Segregating Layer Loader functions similarly to a swinging spout, but it has two distinct advantages. It requires much less headroom, and it is contained in a completely dust-tight compartment.

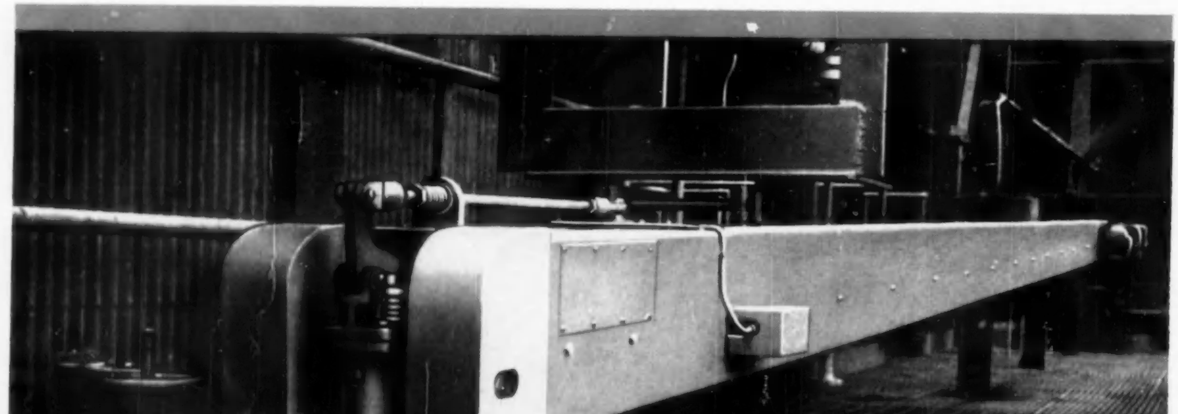
Inside the dust-tight housing of the S-E-Co. Layer Loader is a small, bottomless larry car that is driven back and forth across the stoker hopper. Each time the car passes beneath the downspout, an automatic coal valve allows coal to fill the car. As the car continues to traverse the hopper, the coal flows out the bottom, effectively mixed and distributed.

For complete information write Stock Equipment Company, 745-C Hanna Building, Cleveland 15, Ohio

the Stock Equipment Company Non-Segregating Layer Loader



Vulcan T-30 long cover record at Meramec Station!



This Vulcan T-30 long retractable soot blower has been in operation on Unit 1 at Meramec Station since May, 1956. Fuel for the Combustion Engineering boiler is pulverized coal. Burners are arranged for tangential firing and can be tilted for superheat control.

C-3447

retracts distance

A Vulcan T-30 long retractable soot blower is reaching more than 35 feet between two banks of the pendent secondary superheater on Boiler No. 1 in Meramec Station of Union Electric Company of Missouri. This Vulcan T-30 requires only one outboard hanger to support the extra-rugged framework. Lance travel and rotation are non-synchronized through two driving motors to produce a multi-helix cleaning path to cover different areas of the tube bank while extending and retracting.

Performance of this Vulcan T-30, which is located at the furnace exit where temperatures average 1910 degrees F., led to the selection of Vulcan T-30 blowers with 36-foot travel, RW-3E wall deslaggers and E-4-E rotaries—all under automatic-sequential control—for Meramec's new Unit 3, a Foster Wheeler boiler with separate furnaces, rated at 1,850,000 pounds per hour at 2150 psig and 1010 degrees F., with reheat to 1010 degrees F.

Whether your boiler is large or small, power or process, modern Vulcan soot blowers will help keep it operating at peak efficiency. Your Copes-Vulcan representative has the ideas, information and experience to help you choose the system best suited to your needs.

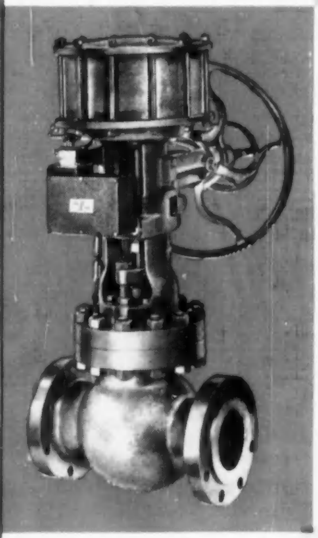
COPES VULCAN

BLAW-KNOX

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

C-V NEWS NOTES

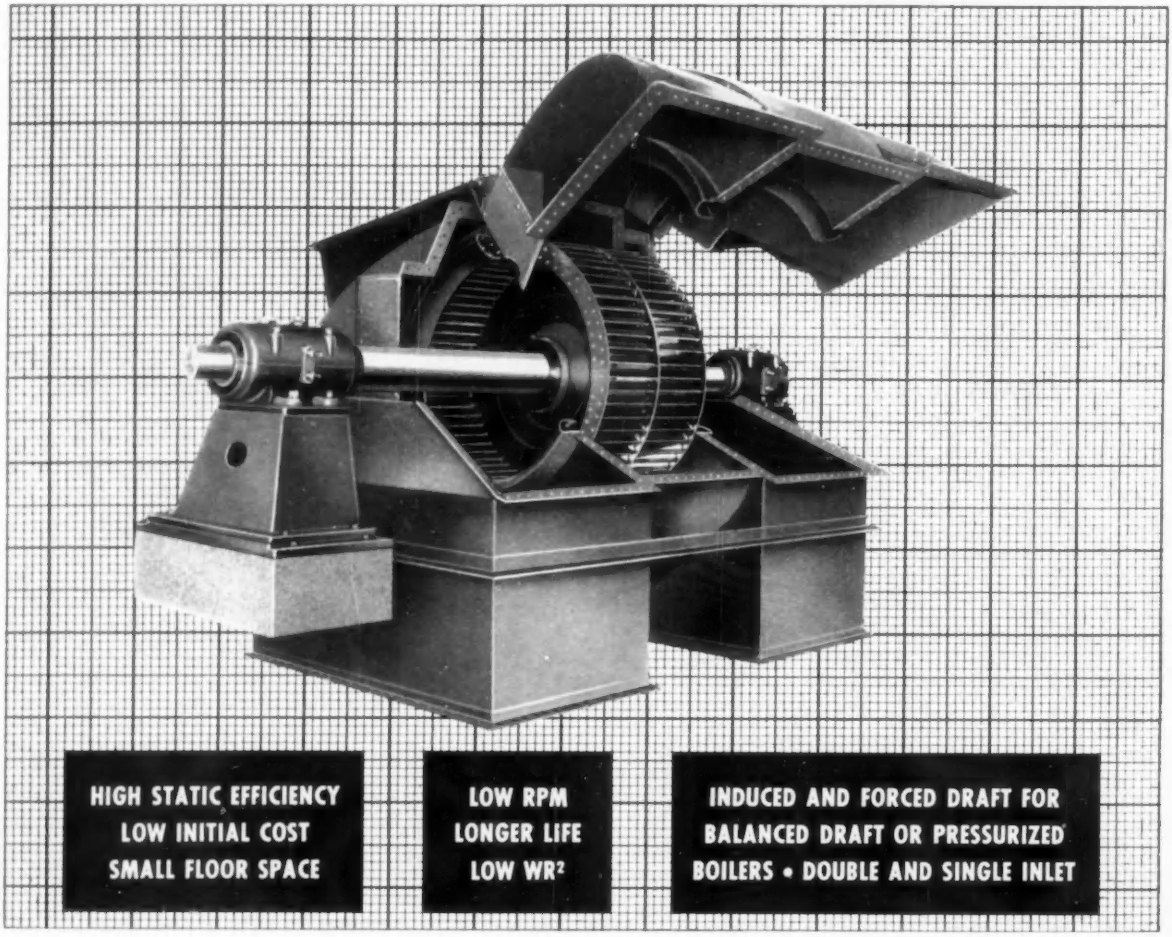
Copes-Vulcan Steam-Assist Desuperheater meets all specifications for conventional steam-atomizing type, yet normally uses assisting steam only on light loads where control is most difficult. Furnished with carburetor body as shown, or for in-line installation. Simple mechanical-atomizing types are also available. Bulletin 1024-A.



Unlimited pressures and sizes up to 16-inch, plus simplified design, are features of the new Copes-Vulcan Types CV-D and CV-P valves. Either diaphragm or piston types are available for pressure, temperature or liquid level control. Bulletin 1027.

Bulletin 1030 illustrates and describes the Vulcan T-30 long retractable soot blower, now successfully operating in temperatures up to 2150 degrees F. (radiant). Your Copes-Vulcan representative can give you a copy, or write direct to the factory.

AMERICAN BLOWER SIROCCO FANS



Look for low initial cost, reduced operating costs, guaranteed performance ratings, minimum maintenance and space requirements. You'll find them *all* in American Blower Sirocco mechanical draft fans.

Specially designed for induced-draft and forced-draft work, Sirocco Fans feature die-formed, forwardly inclined blades for high static efficiency at low rpm's. Streamline, low-turbulence inlets also contribute to high efficiency. And for longer service life, Sirocco Fans have heavy-duty rim and hub plate construction . . . heavy, steel-plate housings and inlets. Special erosion-resistant features are available, as well.

For high efficiency, low cost over the entire operating range, couple Sirocco Fans with American Blower *Gýrol*® Fluid Drive. Infinitely variable in speed, Gýrol Fluid Drive matches fan speed to boiler demand; pays off in longer life for fan wheels and bearings; quieter operation.

If you are investigating mechanical-draft equipment for new or existing installations, take advantage of our experience in air handling. Call your nearby American Blower branch office, today. Or write: American-Standard,* American Blower Division, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard

AMERICAN BLOWER DIVISION

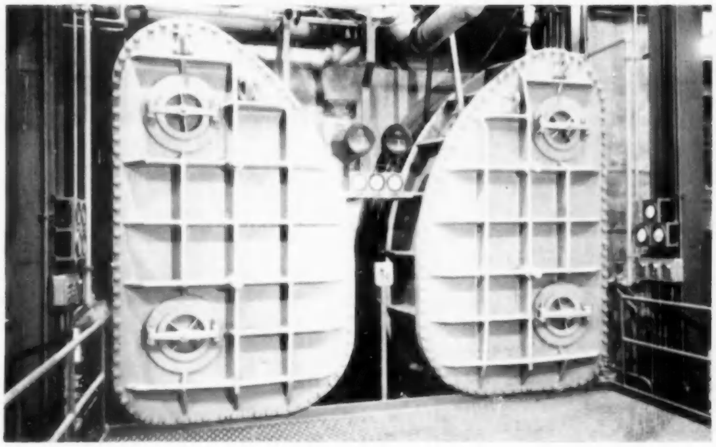
FIRST... The most powerful generator ever built soon will be served by a giant Yuba Surface Condenser which will have 200,000 sq. ft. of heat-transfer surface in a single shell. With a Yuba evaporator, this Yuba condenser will be in operation in Widows Creek Station #7 of the Tennessee Valley Authority. The history-making unit it will serve is a 500,000 KW General Electric reheat turbo-generator: 3600/1800 RPM, cross-compound, double-flow.

FIRST... At Arkansas Power and Light Company, an installation designed by Ebasco Services Inc. will have a 165,000 sq. ft. surface condenser designed and built by Yuba. With seven low and high-pressure feedwater heaters from Yuba, this condenser will serve a Westinghouse single-shaft, tandem-compound, quadruple-flow turbo-generator, the largest of its kind ever built.

Large as these condensers will be, they will also be distinguished by other Yuba characteristics. Their advanced design eliminates the need for excessive headroom. They will be easy to install, not only because of the minimum foundation work required but also because of the precision fit of the sections during re-assembly at the site. Furthermore, in operation, they are certain to show low oxygen content, high heat transfer, and a condensate temperature considerably above the temperature corresponding to saturation pressure.

TWO MORE "FIRSTS" FOR YUBA POWER EQUIPMENT

Yuba power equipment is engineered at Yuba Heat Transfer Division, Honesdale, Pennsylvania; manufactured in the East at the Honesdale plant, and in the West at Yuba Manufacturing Division, Benicia, California. For further information write or call Yuba Heat Transfer Divison, Honesdale, Pennsylvania.



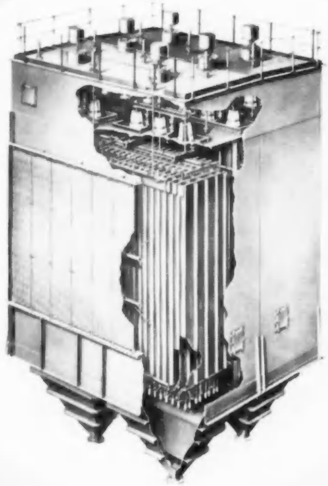
◀ This Yuba Surface Condenser, the same type as those described above, is installed at the Valley Steam Plant, Los Angeles Department of Water and Power.

YUBA CONSOLIDATED INDUSTRIES, INC.

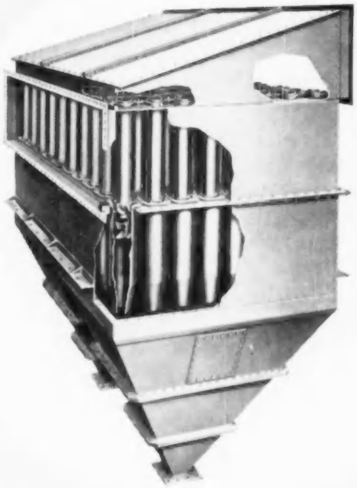
PLANTS AND SALES OFFICES *Nationwide*

YUBA

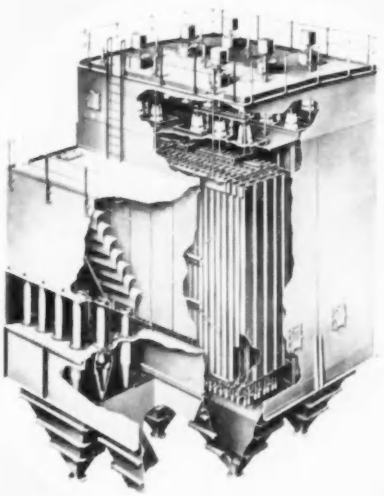
Feedwater Heaters | Evaporators | Structural Fabrication | Cranes



Cottrell
Precipitators

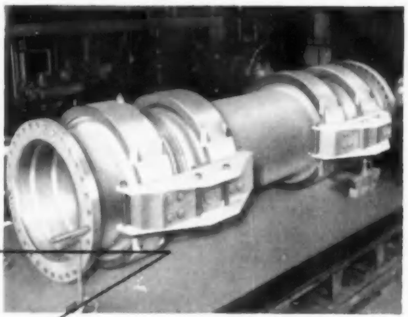


Cyclo-trell
Mechanical Collectors



Combination
Electrical-Mechanical
Collectors

ALL IN A DAY'S WORK at *Pittsburgh Piping*

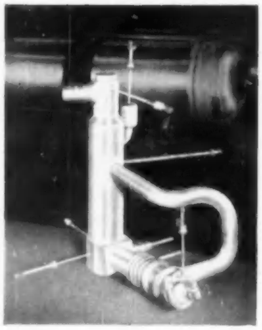


Every Pittsburgh Piping job is different, but all are alike in one respect . . . to control the flow and harness the energy of high temperature steam, gases, or liquids at high pressures. It's all in a day's work at Pittsburgh Piping to fabricate piping for a central station, an atomic energy installation, or for industrial and processing operations. Our service includes every phase from blueprint through erection: engineering, metallurgical control, pipe bending, machining, welding, heat treating, inspection, and testing. Use these facilities on your high temperature, high pressure piping jobs.

this BIG 10-TON EXPANSION JOINT

36" carbon steel joint, weighing ten tons, for cross-over piping in central station.

and this small PRESSURE RISER CONDENSER



Pressure riser condenser, fabricated of Stainless Steel Type 347; 2 feet high; wall thickness equivalent to 4" Schedule 160S. Stainless steel pressure vessel, for atomic energy application, appears in background.

Promoting Progress ***IN POWER AND PROCESS PIPING***

Pittsburgh Piping **AND EQUIPMENT COMPANY**

158 49th Street — Pittsburgh, Pa.

Canada: CANADIAN PITTSBURGH PIPING, LTD., 68 YONGE STREET, TORONTO, ONTARIO

Atlanta .... Whitehead Building
Chicago .... Peoples Gas Building
Cleveland .... Public Square Building
New Orleans .... P. O. Box 74
New York .... Woolworth Building

Hall Industrial Water Report

VOLUME 6 **AUGUST 1958** **NUMBER 4**

Almost 3,000 Billion Gallons of Water

are used each year by the U. S. chemical industry. For all U. S. industry the volume is more than 11,000 billion gallons per year. At this rate industry could drain Lake Erie in eighteen months.

Not all of this water requires treatment but a substantial portion does. Clarification may be all that is necessary for some uses. For others softening, silica removal or alkalinity adjustment may be required. Where very pure water is needed, demineralization may be indicated. Waste water may have to be treated before disposal or to save valuable materials for re-use.

Hall Laboratories has specialized on water problems for over thirty years. Experienced Hall engineers are ready to work with you on your water problems and to help you decide what treating procedures you need in your operations.

Weekly Shutdowns Eliminated

Two boilers in a pesticide manufacturing plant were shut down every weekend for mechanical cleaning. The hard well water used for boiler feed produced scale at a rapid rate despite attempts to prevent this with a "gadget" and later with a cure-all boiler compound.

Then the plant decided to let Hall Laboratories help. The Hall field engineer, with the cooperation of the operating men, soon established conditions in the boiler water which not only prevented new scale formation but removed the old scale at a controlled rate. Now the boilers have operated one year without a shutdown due to scale.

Retubed in Five Months

Three years ago a company operating chemical tank trucks installed a new package boiler for heating and steaming of dirty tanks. Against the recommendation of Hall Laboratories a gadget was purchased to protect the boiler from scale and corrosion.

Five months later a hurry-up call came for a Hall engineer. The boiler had had to be retubed because of corrosion.

Hall engineer M. E. Osmond immediately established water conditions which would protect the boiler. When it was inspected after five months' operation, everyone was pleased to find it clean and free from further corrosion.

The operating men were so impressed that they called on Hall Laboratories again when they ran into trouble. Aluminum tanks, which they were cleaning with a strong caustic soda solution, were corroding. Hall recommended Calgonite® because it is an alkaline detergent which cleans greasy surfaces without attacking aluminum. Once again everyone was pleased when the Hall recommendation solved the problem.

Leaky Baffle Causes Foaming

A Pennsylvania chemical plant suddenly was troubled with severe foaming and carryover of boiler water. When the operators called Hall engineer J. Printz they explained that the trouble was occurring in spite of the fact that the concentrations of phosphate, sulfite, alkalinity and dissolved solids were normal.

Printz collected a sample of boiler water and noticed that it contained a greater amount of suspended solids than normal. He suspected this of causing the foaming.

Why there was so much suspended solids in the boiler water became apparent on investigation. The boiler had operated for awhile with a leak in a furnace baffle which let furnace gases short circuit to the stack without following their normal path through the furnace. This upset circulation in the boiler and permitted sludge to settle out in a section of abnormally slow circulation. The difficulty came after the baffle was repaired when normal circulation stirred up accumulated sludge.

After the boiler was drained and washed to get rid of the sludge, no more carryover occurred.

Special Silica Problem Solved

The Hall engineer was handed a real puzzle when a New England chemical plant asked him to explain why silica deposits were building up in the steam line from a 200-psig pressure boiler and on the diaphragms of the turbine which used the steam. He knew that volatilization of silica in steam does not occur at 200 psig pressure. Something unusual had to be going on. Boiler water silica concentration was normal. The deposits contained small amounts of some salts normally present in boiler water but no phosphate.

A search led to the nitrate converters. In these units water is flashed into steam. This steam at 460°C is introduced to the drum of the 200-psig boiler above the water level. There it mixes with the steam generated in the boiler and goes on to the turbine.

The feedwater to the converters was found to be high in silica. The source of the silica was finally traced to some contaminated condensate from process which was being introduced to the converter feedwater. In a case like this only the experience and training of the Hall engineer enabled him to help the operating men locate the difficulty quickly.

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There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems, write, wire or call address below.

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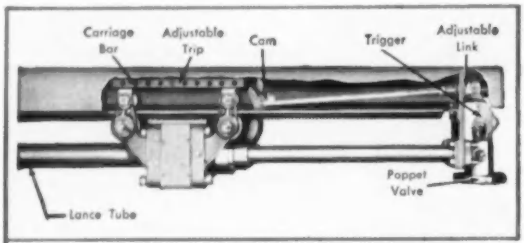
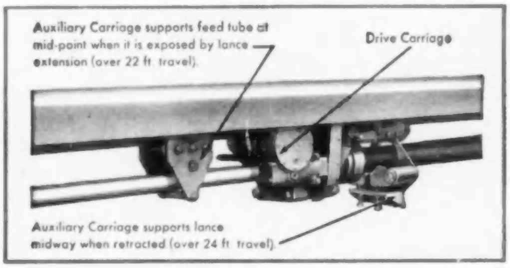


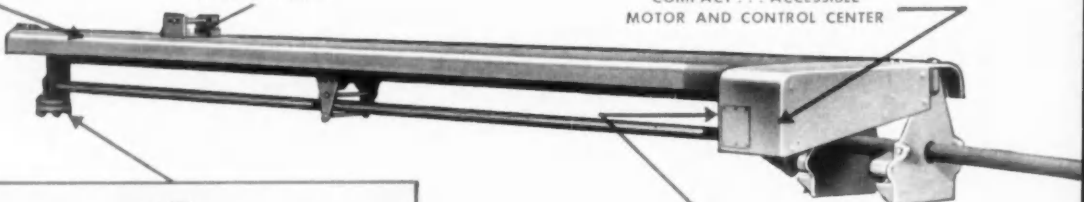
MECHANICALLY OPERATED VALVE

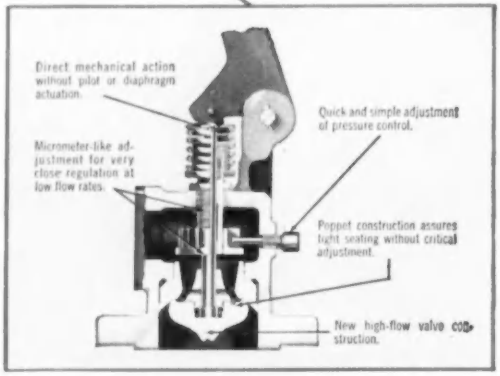
Control of blowing medium is automatic, positive and accurate by means of a simple, dependable mechanically operated valve. As lance begins movement into boiler, trip on carriage opens valve through a linkage. At end of retraction, trip closes valve. All pilot or diaphragm valve elements are eliminated. Trip is adjustable.



AUXILIARY CARRIAGES (FOR EXTRA LONG TRAVEL)

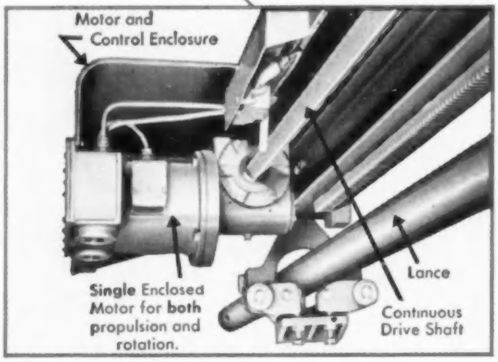
On extra long blowers, one auxiliary carriage supports lance midway when retracted, preventing undue bending. Second auxiliary carriage is dropped at mid-point to support feed tube when it is exposed by lance extension.





POPPET VALVE WITH ADJUSTABLE PRESSURE CONTROL

Diamond dependable poppet valve with improved streamlined flow contours and adjustable pressure control that permits easy, accurate setting of pressure at individual valve and independent of other blowers. Poppet construction assures tight seating without critical adjustment. Stem, seat and disc are stainless steel. Stellited seating surfaces are available.



STATIONARY GEAR MOTOR

Lance propulsion and rotation are by a *single* enclosed gear motor which drives a continuous shaft running the full length of blower and providing power to carriage. This construction makes it possible to mount motor in a fixed position at the front end for better protection and accessibility.

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Diamond

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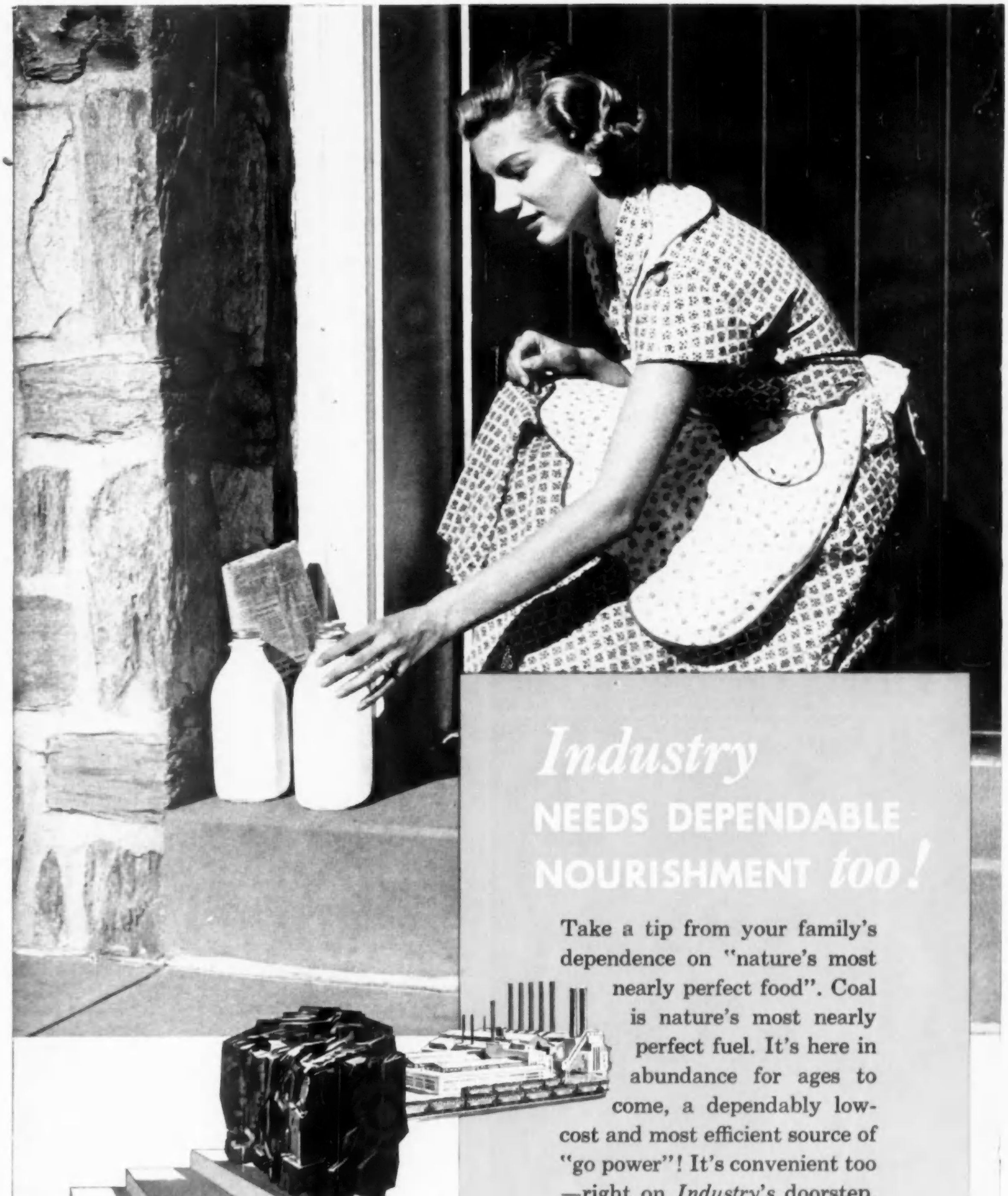
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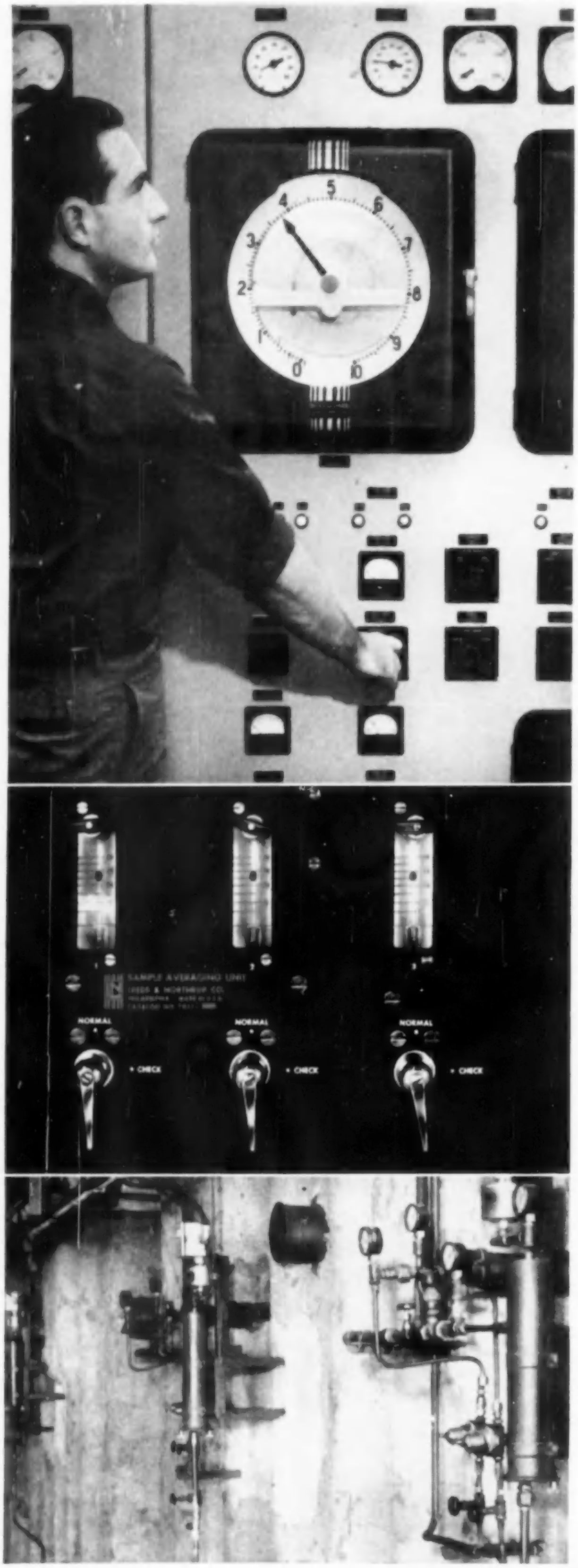

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Why? As one operator put it, "The System gives me a record that's meaningful. When I look at this O_2 chart I know what's *really* happening—and I know it right away."

Behind this operator's confidence is the new L&N Multiple-Probe Sample Averaging Unit which *assures a more representative sample*. This unit maintains a true average from two, three, or more probes—even if individual sample flows drop 60 per cent. And excess air distribution across the duct can be checked right at the Averaging Unit.

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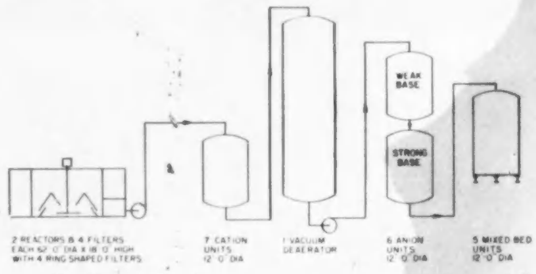

FLOW DIAGRAM 4 BED SYSTEM WITH MIXED BED POLISHING SECONDARY UNITS — Q = 3200 GPM

LINDEN

Cochrane DEMINERALIZER protects high pressure boilers and turbines at Linden Generating Station

WATER ANALYSIS In Parts Per Million

	Raw Water	Final Effluent	
Turbidity	3-46	0 to 0.5	Primary Treatment
Color	40-160	0 to 2	
Total Hardness as $CaCO_3$	26-164	0	Demineralizer
Alkalinity as $CaCO_3$	66-183	0 to 0.1	
Silica as SiO_2	3-12	0 to 0.01	
Dissolved Oxygen as O_2	Saturated	0 to 0.1	
Total Dissolved Solids	100-520	0 to 0.2	

TREATING PLANT

2—Solids-Contact Reactors, 62' dia. x 18' high, with four peripheral gravity anthracite filters.	Primary Treatment
7—Cation Units, 12' dia.	Demineralizer
1—14' Vacuum Deaerator, rubber-lined.	
6—Weak Base Anion Units, 12' dia.	
6—Strong Base Anion Units, 12' dia.	
5—Mixed-bed Polishing Units, 12' dia.	

Public Service Electric and Gas Company's new Linden Generating Station features the most outstanding Demineralizer Plant ever installed. The system, designed and manufactured by Cochrane, treats 30 to 100% make-up for boilers with design pressures up to 2700 psig.

Some of the unique features include complete automatic remote control for both primary treatment and Demineralizer Plant . . . Filter and demineralizer backwash recovery for re-use . . . Re-use of most anion rinse water . . . Low acid consumption . . . Silica reduction in two stages: first, by strong base primary anion units, then by mixed bed secondary units . . . Low caustic soda requirements . . . Resins cleaned by brine automatically. These and many other features assure the ultimate in efficiency for this plant.

Cochrane's years of experience in the design and manufacture of every type of water treating equipment are your assurance of continuing satisfactory performance

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College puts

coal at head of class

Otterbein College saves 42% with coal, installs revolutionary package boiler

Otterbein College, Westerville, Ohio, has discovered truly efficient heat generation. Otterbein's new heating plant burns coal in Coal-Pak boilers—developed by Bituminous Coal Research, Inc.—for automatic performance plus unique simplicity of operation. The result . . . savings in manpower . . . and a spotlessly clean plant.

In addition, comparative fuel cost studies have proved that coal costs 42% less per million Btu than the nearest competitive fuel in this area . . . a bonus savings! And, in keeping with the modern operation of this plant, the entire interior has been brightened by an attractive color scheme.

Facts you should know about coal

You'll find that bituminous coal is not only the lowest-cost fuel in most industrial areas but up-to-date coal burning equipment can give you 15% to 50% more steam per dollar. Today's automatic equipment can pare labor costs and eliminate smoke problems. And vast coal reserves plus mechanized production methods mean a constantly plentiful supply of coal at stable prices.

Technical advisory service

To help you with industrial fuel problems the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to the address below. Or send for our case history booklet, complete with data sheets. You'll find it informative.

Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—can effect great savings for you in efficiency and fuel economy over the years.

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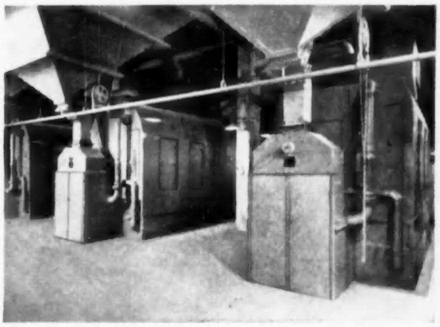
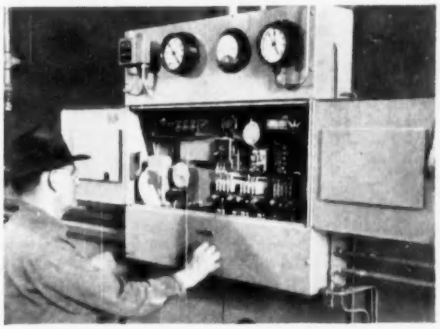
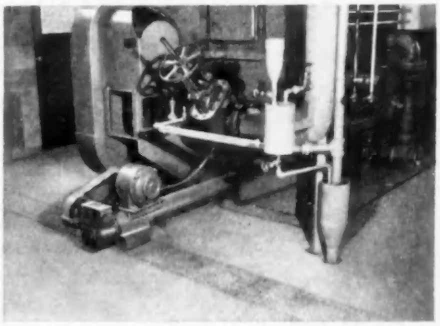


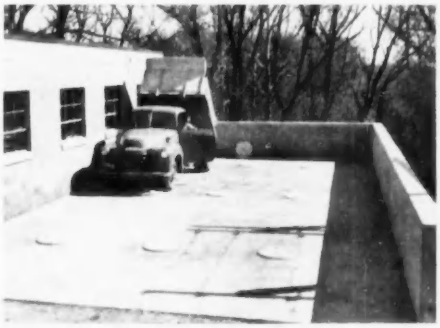
Heating plant at Otterbein showing the three Coal-Pak Automatic Water Tube Generators, by International Boiler Works Co. (Licensed under pending patents of Bituminous Coal Research, Inc.) Coal storage hoppers at top of photograph hold 30-35 tons of coal each.



Single switch on front of cabinet enables operator to change from "run" to "hold-fire" operations. Each generator has its own rugged, non-electronic combustion control system, housed in tamper-proof locked cabinet. It controls safely and efficiently the starting-up sequence, coal feed, fuel-air ratio, hold-fire operation and ash removal.



Rear of generator, showing part of dustless ash disposal system. Ash removal is an integrated feature of the package operation—no manual handling. Ashes are removed by screw conveyor. They pass into main screw conveyor recessed into the floor (covered by metal plate) and are carried outside.



Coal is delivered by truck and dumped through any of nine manholes into storage hoppers below. From hoppers, it is gravity fed into stokers. Four-foot wall around coal dumping platform permits use of platform for outside coal storage, holding additional 250 tons.

COMBUSTION

Editorial

The Race For Information

A recent issue of "The Frontier" published by the Armour Research Foundation of Illinois Institute of Technology carried an article by the literature chemist at the Foundation on a solution to the problem of keeping abreast with the written results of research. As an example of the enormity of this problem Mrs. Wennerberg, the literature chemist, cites the growth of the dicennial index to chemical abstracts from six volumes in the 1937–1946 issue to 19 volumes in the 1947–1956 publication. Moreover, as the author points out, today's race for information must include foreign technical literature which demands prompt and regular review plus the U. S. Government's output—a relatively minor quantity up until the War but now a truly tremendous volume—and the traditional outlets, the engineering society and technical journals, industrial and research foundation reports. Truly, a prodigious task.

Some three years ago we published the observations on this subject of Glenn B. Warren, General Electric Co., recently nominated for the post of president of the ASME for next year. Among Mr. Warren's observations was the highly significant statement "We may have to carry out an idea suggested by Dr. Vannevar Bush, namely, to assemble in some place all of these (information and available data) properly coded, etc., in the memory of one of these new giant computing machines. Then, when an engineer or scientist has a problem, he can put his questions to such a computing machine and perhaps in less than ten minutes have it turn out in print a synopsis of the answers of all pertinent reports recorded. This may seem fanciful today (March 31, 1955) but I doubt if it will be a few years hence." In the vernacular of the day, how right you were, Mr. Warren.

Coding, of course, has long been recognized as an effective means of breaking such an imposing task down to manageable proportions. At Armour apparently the design of adequate code systems is a continuing process and refinements are being instituted toward adaptation of code systems to machine-sort cards as well as mechanized searching procedures. But, as always, a human skill is needed to properly mine the wealth of coded information now accumulating. Let us quote Mrs. Wennerberg:

"The recognition of literature research as a distinct and specialized area of research does not completely free the organization from literature chores. The research staff must have confidence in the information specialists to whom the selection of significant information is entrusted. The prime objective of ARF's research information staff is to select and handle specific information with the same degree of technical competence that is expected of other research personnel. The job of the searcher, in essence, is to distill vital information from the mass of indiscriminate data available in the literature."

This last named individual, the searcher, shares something of a kinship with the average editor of a technical publication. The editor should attempt to employ the pages of his publication to interpret and disseminate vital information in the specialized field of the magazine's coverage and thereby make available in the literature new developments and future trends as he sees them unfold. In a modest way we are trying to do our part.

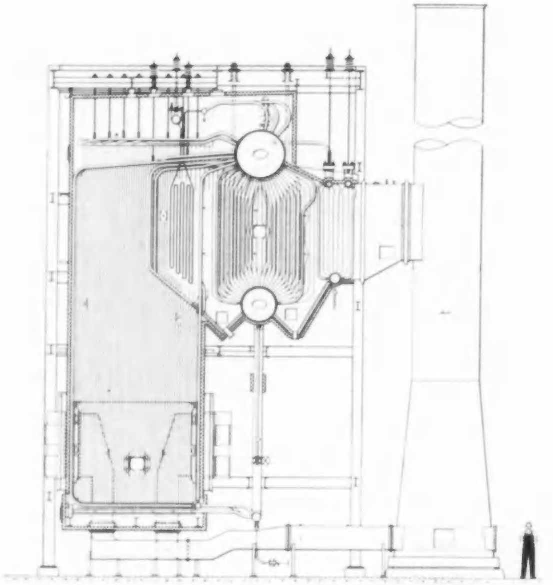


Fig. 1—Standard Combustion Engineering Type VU pressurized furnace tangentially fired with conventional waterwalls, above, serves well as a CO burning unit. It can use oil for enrichment or fire the oil independently if desired. The result is a flexible addition to steaming capacity

The CO Boiler of Standardized Design—

Effective Answer to Economic Recovery of Refinery Waste Heat

By T. J. Harvey[†] and P. C. Trounce[††]

Canadian Oil Companies, Ltd.

Regeneration of the catalysts in modern refineries imposes special problems from the control of regenerator bed temperatures to the disposal of large quantities of a low Btu gas. The CO boiler has put the low Btu gas together with its sensible heat to economic use. Here is how the refinery engineer has applied this boiler to circulating catalytic systems and yet retained the boiler's independence so it can be fired alone when the regenerator is shut down.

SINCE 1938 the petroleum industry has been actively developing methods of applying catalysts in the production of gasoline. Over the course of the years the problems of the regeneration of these catalysts and then later the disposal of their waste by-products have proved to be serious tasks.

For the present so-called circulating catalytic systems—fluid catalytic, Thermofor, Houdriflow—the advent of the CO boiler has solved satisfactorily the disposal of the waste gases from the regeneration of their catalysts.

† Chief Engineer
†† Engineer

A simplified review of the manner in which the CO boiler fits into the refinery cycle indicates some of the reasons for the boiler's effectiveness.

Development of the CO Boiler

These circulating catalytic systems, mentioned above, have the catalyst move through the oil zone to expedite the desired reactions and then into a regeneration zone where air continuously burns the coke deposits (carbon and hydrogen) from the catalyst. The gaseous combustion products resulting from this operation create the disposal problem the CO boiler is able to eliminate.

Unfortunately the combustion process for regenerating the catalyst cannot be carried out under ideal conditions. Each particular catalyst to be properly regenerated imposes restrictions of its own on the rate at which the coke can be burned off it. Sintering at high temperatures, for example, deactivates these catalysts and hence the regenerator-bed temperature is limited to about 1100 F for a synthetic catalyst and about 1070 F for a natural one. Moreover, the present method of catalyst regeneration requires that the air be admitted to the cycle under considerable pressure, about 20 psig. The cost of compressing the air volumes involved runs high and therefore the excess air admitted to the process is held as low as pos-

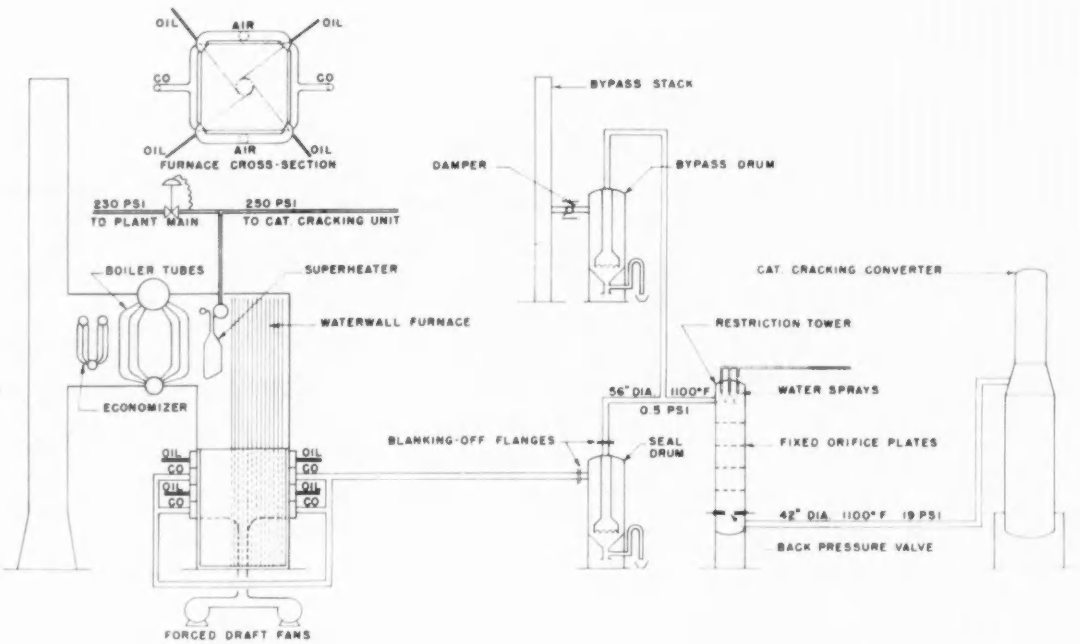


Fig. 2—Flow diagram shows the low Btu content gas leaves cat cracking converter, far right, enters a restriction tower, passes through seal tanks or drums that act as check valves to separate boiler and catalytic systems and out of these seal drums into the CO boiler, bottom, or to bypas, top

sible. As a result considerable quantities of a low Btu content (roughly 15 Btu per cu ft) CO-bearing gas issues from the catalyst regenerator at a temperature of about 1000 F. This gas, an air pollutant, was discharged as a general practice directly to the air before the advent of the CO boiler. Further it was discharged at high velocity and unless amply muffled could be objectionably noisy. The CO boiler overcomes these objections.

The Sarnia Decision

In 1954 when a plant expansion program was planned at the Canadian Oil Companies, Ltd., Sarnia Refinery, the need for additional steam generating capacity came up for consideration. It was decided to install a boiler of the same output as the two existing boilers, namely, 100,000 lb per hr at 250 psig. Further it was decided to investigate the feasibility of a CO boiler.

The CO boiler from the refiner's standpoint combines the features of waste heat recovery equipment and a conventional boiler. It generates steam by burning the CO in the regenerator flue gas and recovering this heat as well as the sensible heat of the gas. This waste heat feature offers an attractive return in fuel savings. Moreover steam production need not be limited by the heat available in the waste gas. Oil is fired with the waste gas to increase steam production or oil can be fired alone to deliver full steaming capacity when the cat cracker is shut down. The combination of fuel savings from waste heat with a flexible source of steaming capacity aroused considerable interest at Sarnia.

There were, however, a number of special requirements that any proposed CO unit would have to meet for successful incorporation into the Sarnia Refinery. First and foremost was the steaming requirement of an additional 100,000 lb per hr capacity. Consultation with the boiler manufacturer indicated that a CO boiler capable of delivering 100,000 lb per hr of steam would be just about the right size for the available regenerator gas.

Secondly some indication was sought as to the expected fuel savings for a CO unit of this size as compared with a conventional boiler. This comparison proved highly important in the early decision stages. Below are the fundamental steps in such a comparison.

Heat requirements for a 100,000 lb per hr steam boiler at 250 psig, CO or conventional, are:

Evaporation	100,000 lb per hr
Enthalpy at 550 F, 250 psig	1290 Btu per lb
Enthalpy at 250 F feedwater	212 Btu per lb
	1072 Btu per lb

Heat absorption, 100,000 lb per hr × 1072 = 107.2 million Btu per hr

For a conventional boiler with 100,000 lb per hr of steam generated from fuel oil and at an efficiency of 82 per cent, 131 million Btu per hr of heat would have to be supplied.

For the CO boiler delivering 100,000 lb per hr where oil has to be fired to maintain the combustion of the CO gas approximately 63 million Btu per hr of heat are supplied by oil, 45 million Btu per hr come from the heat of CO combustion and 54 million Btu per hr come from the sensible heat in the regeneration gas for a grand total of 162 million Btu per hr. The efficiency of such a unit is 107 million Btu per hr of heat absorbed out of the 162 million supplied. The figure of most interest to the operation of the refinery is the low requirements for fuel oil. The CO unit's demand of 63 million Btu per hr

from oil as against 131 million Btu per hr need of the conventional boiler represents a 68 million Btu per hr saving.

It is safe to assume an 8000 hr operating year and fuel oil at a cost of 40 cents per million Btu. Then the 68 million Btu per hr fuel oil saving amounts to about $200,000 per year.

Design

These conclusions and similar favorable findings on other points of investigation led to the decision to install a CO boiler. From the very outset the tangential firing principle offered an excellent way of achieving these desired conditions. This method had worked successfully for a number of waste fuels occurring in other industries and from a study of the experiences in these applications it proved possible to employ at Corunna a standard unit, namely the Combustion Engineering Type VU pressurized furnace outdoor design. This unit, Fig. 1, is a conventional waterwall model with tangential firing from all four corners to promote good turbulence and thorough mixing for fast combustion.

A reference to Fig. 2 will show how the selected CO boiler fits into the refinery cycle. The regenerator discharge gases leaving the regenerator, or convertor as it is labeled in Fig. 2, far right, pass through an air-motor-driven, flat-plate slide valve and four fixed orifice plates in the restriction tower to hold a constant back-pressure in the regenerator. It was found possible to revamp the former stack complete with all fitments to become the present restriction tower by addition of a skirt and an outlet head Figs. 3-6.

At times when the boiler is not in operation, the gases pass to a bypass stack and the main seal drum is filled with water above the level of the bottom of the inner pipe. At such time, to protect the unlined carbon steel bypass stack, water sprays at the top of the restriction tower are used to reduce the gas temperature to 700 F. These sprays may also be used if possible "afterburning" should occur when, due to unit upset, the CO may burn in the ductwork in the presence of excess regeneration air and produce temperatures of the order of 1300–1400 F. A partial damper is provided at the bypass stack so that, when switching the gas to the boiler, when both seal drums are empty of water, enough pressure is available to ensure flow to the boiler against furnace pressure.

In view of the very large mass-flow of gas leaving a CO boiler it is economic to omit the usual induced-draft fan and use a sealed pressurized unit with forced-draft fans only.

Major ductwork, Fig. 7, conveying the regenerator discharge gas is refractory lined to reduce expansion problems, heat losses and personnel hazard. This refractory lining in the carbon steel ductwork consists of 2-in. V-block mix insulation and 1-in. Furnascrete hardface gunned into Hexteel. The ductwork metal temperature employed for expansion calculations in the design stage was 400 F. Actual operating temperatures run nearer 200 F. The design gas velocity was established at 150 ft per second. Flat bar rings are recommended for the shell of the ductwork at every 1½ diameters to prevent gas channeling along behind the refractory.

The ductwork, incidentally, near the boiler is bare steel, unlined, since it is of small I.D. There is considerable relative movement between boiler and seal drum, Fig. 2, as a result of the ductwork and boiler expansion. Stainless 10 gage 18-8 slip joints are installed to provide a smooth I.D. thereby avoiding turbulence. The ductwork at the boiler is supported by deadweight and spring hangers.

Seal Drums

The seal drum, Fig. 2, a vital connecting link between the CO boiler and the waste regenerator gas stream, is of bare steel A-201, Grade A for high temperature creep strength, ½-in. walls and 9-ft diameter. The drum external carries rock wool insulation and a sheet metal covering. The cone bottom is attached to the shell with radiused knuckle with all cone welds X-rayed as a pre-

Fig. 3—Photo sequence of Fig. 2. begins with converter regenerator, far right, through 42-in. diameter ductwork to restriction tower, left

Fig. 4—Gas flows upward through restriction tower, above, to 56-in. diameter ductwork leading to seal drums or tanks, Fig. 2

Fig. 5—Ductwork enters active seal drum at ductwork base or bypass drum. Stack, far left, is for boiler, second stack is for bypass drum

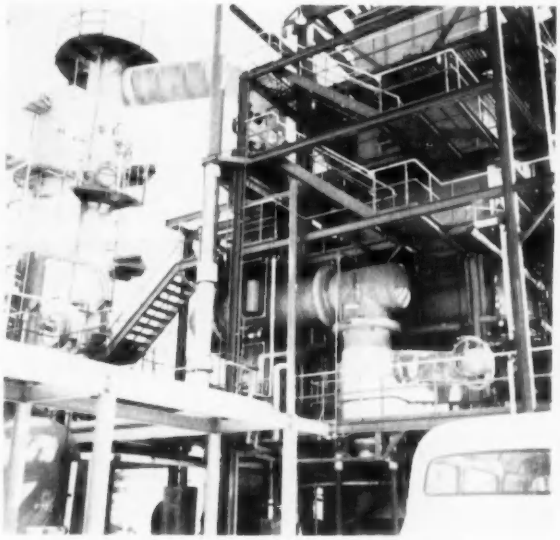


Fig. 6—Side view of the CO boiler shows gas duct tying into the CO burner manifold which supplies burners at the boiler corners

caution against the very large stresses occurring when cold water is admitted to the cone for sealing purposes while the drum metal is at 1000 F. Inlet and outlet ducts are flanged to permit blanking. Flexitallic gaskets are used. The shell itself expands and contracts over 1/2-in. in diameter so it is mounted on a flange on the skirt with brass shims to permit sliding. The shell expands up 1 in. so that a flat top flanged-only head was employed to soak up the expansion.

Incoming regenerator waste gas flows down the center pipe and up the annulus to the outlet duct connecting to the boiler. The bottom of this center or dip pipe is toothed 12-in. deep and its diameter increased to half the area of the seal drum shell for smooth sealing. The water for filling the seal drums comes through a 6-in. line into an 18-in. manway in the cone. In normal operation there is a small bleed of water into the dead seal pot and out to a weir to maintain water level.

Bypass Drum

This unit is a duplicate of the seal drum with one major exception. The bypass drum discharges through a butterfly valve or damper to the bypass stack. This valve is of extreme importance when switching discharge gas into a pressurized boiler. The butterfly must be closed enough so that the discharge gas reaches the seal drum with enough pressure to overcome furnace pressure rather than vice versa.

Instrumentation

The major operating elements of the CO boiler are under automatic control and the system, a pneumatic one, Fig. 8, was supplied by the Bailey Meter Co. The system comprises three parts, namely, steam pressure control, a three-element feedwater control and a combustion control. The control panel has been housed in the control room of the Catalytic Cracking Unit.

Steam Pressure Control. Since the CO boiler supplies steam to both the Catalytic Cracking Unit and the main Refinery System, steam pressure control is accomplished by two pressure transmitters, one on the CO boiler outlet set at 250 psi and the other on the Refinery Header set at 235 psi. These two transmitters operate through air relays to control a valve which normally spills surplus CO boiler steam to the Refinery main, or vice versa, if the CO boiler is shut down.

Feedwater Control. This is a conventional three-element feedwater control system. It maintains boiler drum water level constant for variations in steam flow, water flow and water level.

Combustion Control. This provides for the regulation of fuel oil and atomizing steam in response to steam output from the CO boiler. In addition it positions the forced draft inlet vanes in response to steam flow variations. The position adjustments maintain a unity relationship between oil flow and the air volume supplied to burn this oil. A manual loading station assists in maintaining this relationship between air and oil flow by permitting adjustments for any variations in the flow of the cat cracker flue gas. Lastly an oxygen and combustibles analyzer on the boiler stack serves as a further guide for the operator in achieving proper combustion.

Normally the motor driven forced draft is in operation controlled from the remote control room. A three-way solenoid valve is installed on the air line from the manual station to the control valve on the turbine-driven fan and is electrically closed when the fan motor is operating. The turbine manual control is always in the open position so when a power failure occurs the turbine fan automatically starts.

Additional Instruments. A manually controlled water quench cools the flue gas directed to the by-pass stack.

A manual control station either increases or decreases total steam flow from the CO boiler automatically.

Alarms have been provided for these functions: (1) low pressure – boiler feedwater, (2) low pressure – fuel oil, (3) low pressure – steam header, (4) low flow – combustion air, (5) high level – flash drum, (6) high-low level – steam drum.

An automatic gas pilot ignition system is also installed in addition to numerous test orifices, temperature points and pressure gages to give all necessary information.

Operation and Maintenance

(1) To put the boiler on stream after a shutdown, it is first started up as an oil-fired unit in the usual way, on hand control, with the CO gas bypassed and with the duct water sprays in operation to reduce temperature, Fig. 2. See also control diagram, Fig. 8.

The boiler is then put on automatic, and the load brought up to about 80 per cent. At this time, if the cat cracker is in satisfactory operation, the switch is made.

The damper in the bypass is pinched down. The boiler seal pot is emptied. The bypass seal pot is filled. The burners are then reduced from eight to four, and fan air flow is adjusted for optimum conditions. The duct water sprays are turned off. The gas pilot burners are normally left in operation.

Shutdown is identical in reverse.

(2) During one experience of afterburning in the cat cracker, it was unfortunate in that the duct water sprays were out of commission due to a faulty control valve. This was soon after the initial startup.

The afterburning condition lasted for about 24 hrs and the temperature of the CO gas varied from normal to 1400 F plus, several times, for hours at a time.

At the peak of the surges, the steam production rate went off the chart completely and there was danger of losing water level due to insufficient supply. The drum safeties blew due to extra pressure drop through the superheater.

However, the boiler stayed on line successfully and there was evidently no damage to any part.

It is not known whether the effect, that is the afterburning, was an unusually high content of CO in the gas, or carry through of cat cracker feed oil.

It is felt that this condition can be adequately met by use of water sprays, whose purpose is to soak up Btu's in latent heat which is not recoverable in the boiler.

(3) Operation Record: The unit went into operation in November 1955. During its life it has only been shut down when the cat cracker was also shut down for scheduled maintenance. This was in May 1956 and March 1957.

At the first shutdown, changes were made to the fd fan dampers, the floor refractory was replaced, two superheater elements were removed and bypasses fitted, a purge air connection to the CO gas manifold was fitted, and the unit was cleaned. Other minor work was performed.

At the second shutdown, three other superheater elements were removed and general cleaning was carried out. This is quite minor and consists mostly of hosing down the surfaces. There are no major accumulations of catalyst dust or soot. There is no appreciable erosion or corrosion.

Up to the end of this September, out of 700 calendar days from startup, the unit has operated 636 days, equal to 8000 hrs a year.

Steam production per operating hour has averaged 91,400 lb per hr. Steam production per calendar hour has averaged 86,100 lb per hr.

(4) Economics: Our feeling is that a decision to install a CO boiler is based on one of two reasons.

(*a*) Payout because of fuel saving. If this boiler backs out steam from conventional boilers, then the cost of the whole installation must be compared with the fuel savings.

(*b*) If the refinery needs more steam because of added process facilities, then these facilities should bear the payout of at least a conventional boiler. The incremental cost of a CO boiler is then chargeable to fuel oil savings and the payout on this basis is very rapid.

(5) Maintenance: We are looking forward to good

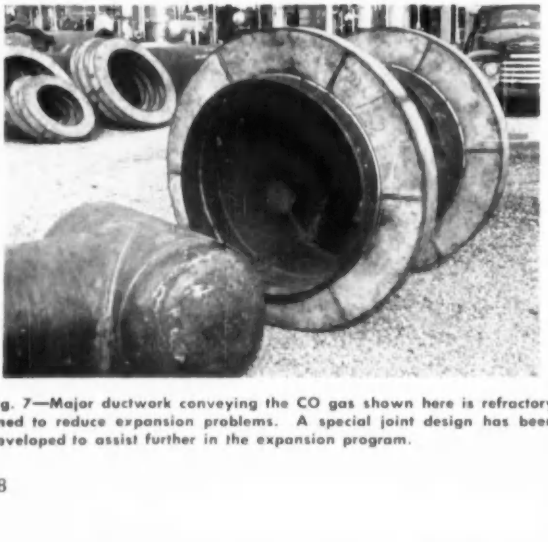


Fig. 7—Major ductwork conveying the CO gas shown here is refractory lined to reduce expansion problems. A special joint design has been developed to assist further in the expansion program.

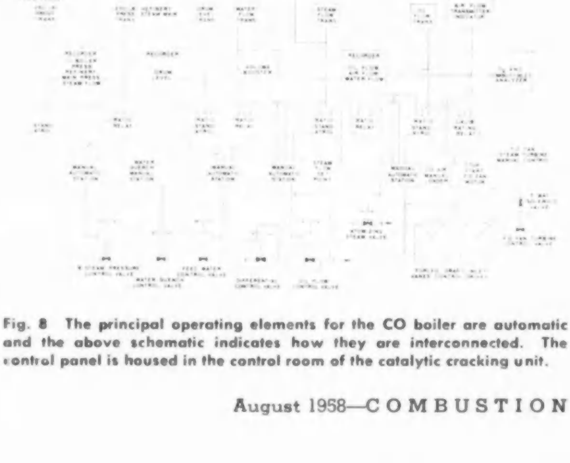


Fig. 8 The principal operating elements for the CO boiler are automatic and the above schematic indicates how they are interconnected. The control panel is housed in the control room of the catalytic cracking unit.

maintenance costs. Refractory history should be better because of lower temperatures. Corrosion should be better because of lower flue gas dewpoint.

However, there is additional equipment over conventional and this will have maintenance expense.

It should be borne in mind that a CO boiler's load is not seasonal and in general, will be close to design (it is tied to cat cracker gas production), assuming it was not originally purchased any larger than necessary. It will therefore have a high load factor.

(6) Initial considerations: (A) The boiler size depends upon several factors:

Cat Cracker Regeneration Air Rate. Bearing in mind later improvements in the unit which, in general, will increase the rate and improve its acceptability.

CO Percentage. Depends on the design of unit and type of catalyst used. May increase with design changes. A good gas analysis is called for.

Additional Steam Production Required. Incremental steam is expected to be produced at lower thermal efficiency than in a conventional boiler, but each installation requires study of the economics of additional operaters, boiler auxiliaries, etc., versus incremental boiler size dollars at lower thermal efficiency.

(B) There is a natural hesitation on the part of process personnel to add equipment to a process unit which is not an essential part of that unit.

However, it is well demonstrated that there is no way the usual CO boiler can affect the process unit to any degree, even in violent upsets.

Combatting Ice Formations at Dockside

Two research engineers were reported late this past March to have come up with a device that could save millions of dollars annually by preventing ice damage to piers, docks, and boats during winter months.

According to the report they had developed a heat exchanger which this past winter completely eliminated ice from an area around a large pier installation at Lake Geneva, Wis.

The engineers are George E. Gross, administrative supervisor and William F. Cramer, Jr., senior engineer, both at Armour Research Foundation of Illinois Institute of Technology. Their winter project was an off-hours activity.

Using the principles of heat exchange and the upsetting of stratification of water required for freezing, the unit they have developed is inexpensive, portable, and can't be damaged in normal use.

An added feature is the ability to regulate the direction of the unit's effectiveness to melt almost any pattern in the ice needed or desired.

The cost of the initial installation would vary with the type of protection needed and the size and location of the pier, Gross said.

A unit similar to the one built for the Lake Geneva pier would cost about $500 initially, and $16 a year to operate. In most cases, the initial cost would be far less, and maintenance costs would be low, according to Gross.

To remove and re-install the pier at Lake Geneva in the usual manner each fall and spring would cost approximately $1,200 a year, he said.

The 70-pound pilot unit was put in operation under a pier belonging to Herbert Johnson, 8333 Niles Center Rd., Skokie, Ill., a contractor who plans to make the units available commercially. The 62-foot long and 12 foot wide pier is located in a corner of Button's Bay in Lake Geneva.

Gross and Cramer have checked the operation of the unit every Saturday since ice formed on the lake.

They found that the water surrounding the pier maintained a temperature of 35 degrees, even through the coldest weather which reached 20 degrees below zero. At no time were the pier's posts in danger, Gross said.

With a slight adjustment, they could raise the temperature to 37 degrees, and they believe it is possible to approach 40 degrees at this location.

At 35 degrees, the unit was operating at only 38 per cent efficiency. At this rate, they estimated the device compensated for the freezing of roughly 30,000 pounds of ice in 10 hours.

Nature provides an added advantage to the unit, Gross said. Because the water around the pier is darker than the surrounding ice, it absorbs light, causing the heated area to warm itself naturally.

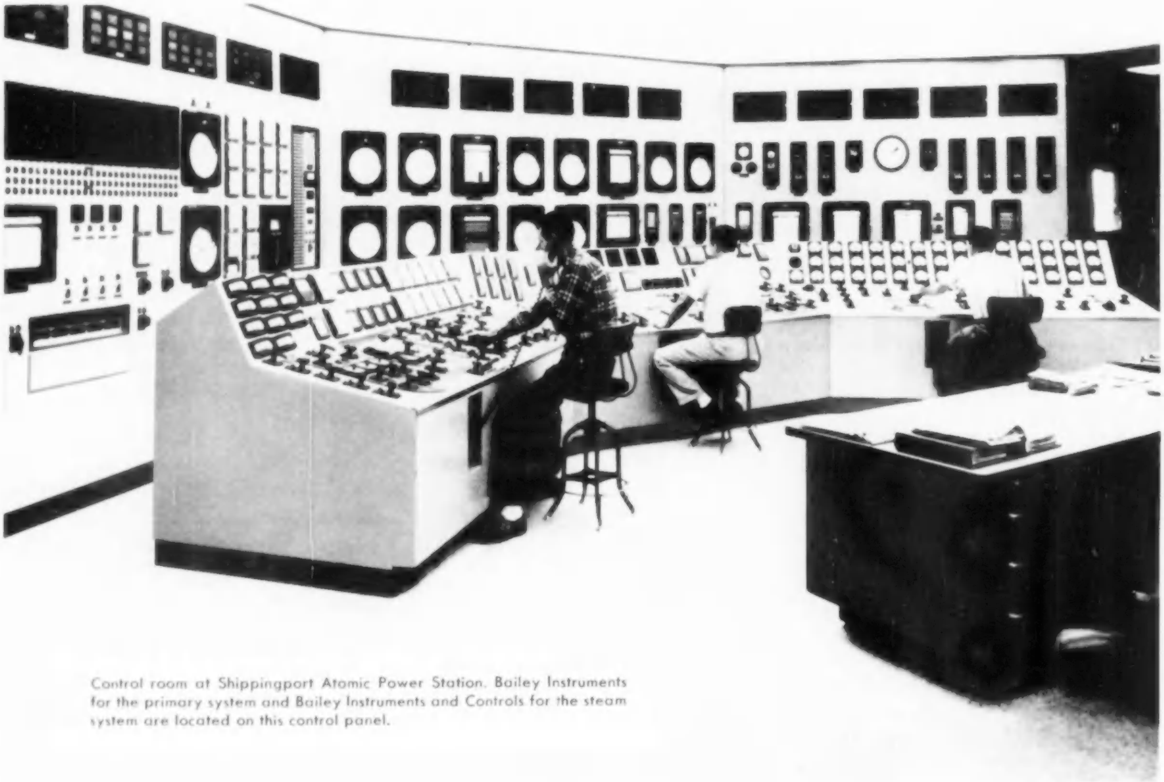
Gross pointed out that future research on the heat exchanger has many possibilities. Experiments indicate that a device using the same principles would be feasible and relatively inexpensive for keeping Great Lakes locks open the year round.

In fact, it is conceivable that with sufficient research, employing known methods and combinations, entire ports and shipping lanes could be kept open in normally ice-bound areas, he said.

Also, lagoons and harbors could be made ice-free for keeping boats in the water throughout the winter.

The unit would have many applications for emergency use, too, for keeping areas open where ice forms only during extreme cold weather.

Gross has applied for patents on the unit.



Control room at Shippingport Atomic Power Station. Bailey Instruments for the primary system and Bailey Instruments and Controls for the steam system are located on this control panel.

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A136-1

Instruments and controls for power and process

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In Canada—Bailey Meter Company Limited, Montreal

By IGOR J. KARASSIK*

Worthington Corp.

The boiler feed pump and its associated equipment represent a major operating and maintenance consideration in today's power plant. Here begins in question and answer form a series of three clinic sessions on various boiler feed pump problems. The replies are the work of one of the topmost pump authorities and give specific information which we hope will prove valuable to our readers.

Steam Power Plant Clinic—Part I

QUESTION:

We have experienced seizures of boiler feed pumps shortly after the initial start-up, and traced these difficulties to the presence of foreign matter in the lines. This foreign matter apparently gets into the clearance spaces in the pump and damages the pump to a considerable extent. What special precautions are recommended to avoid such difficulties?

ANSWER:

Boiler feed pumps have internal running clearances from 0.020 in. to as low as 0.012 in. on the diameter (that is from 0.010 in. to 0.006 in. radially) and it is obvious that small particles of foreign matter such as mill scale left in the piping or brittle oxides can cause severe damage should they get into these clearances. Incidentally, it has been the general experience that an actual seizure does not occur while the pump is running, but rather as it is brought down to rest. But since boiler feed pumps are frequently started and stopped during the initial plant start-up period, seizures are very likely to occur if foreign matter is present.

The actual method used in cleaning the condensate lines and the boiler feed pump suction piping varies considerably in different central stations. But the essential ingredient in all cases is the use of a temporary strainer located at a strategic point.

Generally, the cleaning out starts with a very thorough flushing of the condenser and deaerating heater, if such is used in the feedwater cycle. It is preferable to flush all the piping to waste before finally connecting the boiler feed pumps. If possible, hot water should be used in the latter flushing operation, as additional dirt and mill scale can be loosened at higher temperatures. Some central stations use a hot phosphate and caustic solution for this purpose.

Temporary screens or strainers of appropriate size must be installed in the suction line as close to the pump as possible. It is difficult to decide what constitutes sound practice in choosing the size of the openings. If 8 mesh screening is used, and assuming that 0.025 in. wire is used, the openings are 0.100 in. and that is too coarse to remove particles large enough to cause difficulties at the pump clearances which may be from 0.006 in. to 0.010 in. radially. If there is an appreciable quantity of finely divided solids present and if the pump is stationary during flushing, some solids would be likely to pack into the clearances and cause damage when the pump is started.

The safest solution consists of using a strainer with 40 to 60 mesh and flushing with the pump stationary, until the strainer remains essentially clean for a half day or longer. After that, a somewhat coarser mesh can be used if it is necessary to permit circulation at a higher rate. But it is very important that the pumps be turned by hand both before and after flushing to check whether any foreign matter has washed into the clearances. If the pump "drags" after flushing, it must be cleared before operating the pump.

Unless the system is thoroughly flushed before starting the pump, the use of a fine mesh screen may cause trouble. For instance, 40 mesh screening with 0.015 in. wire leaves only 0.010 in. openings and these would clog up instantly, unless a very thorough cleaning job was done initially.

Pressure gauges *must* be installed both upstream and downstream of the screen and the pressure drop across it watched most carefully. As soon as dirt begins to build up on the screen and the pressure drop starts to climb, the pump should be stopped and the screen cleaned out.

This brings us to the question of the type of strainer best to be used. While the conventional flat screen strainer placed between two flanges has been used very frequently and is inexpensive, it is not really an economical solution. Considerable expense is involved in removing, cleaning and replacing such strainers and requires pipe fitters to be on duty to break and make the joints.

One of the most satisfactory types of strainers is the type illustrated in Fig. 1. It has a sloping screen which affords a lower pressure drop and hence longer periods between cleaning than the conventional flat screen strainer. It is provided with a draw-off cock for removing accumulated foreign matter. Thus, in many cases, dirt accumulation can be dropped out by opening this draw-off cock without actually shutting down the system. The strainer is also provided with a valved opening on

* Assistant to Vice President and Consulting Engineer, Harrison Division

its downstream side, permitting to back-wash the screen if necessary. Operators have reported that it is possible to clean a strainer such as this in a total of ten minutes of complete outage time as against approximately four hours required for the conventional flat strainers.

If the size of the free straining area is properly selected to minimize the pressure drop, the start-up strainer may be left in the line for a considerable period before the internal screen is removed. Alternately, the entire unit may be removed and replaced with a spool piece. The strainer is then available for the next initial start-up.

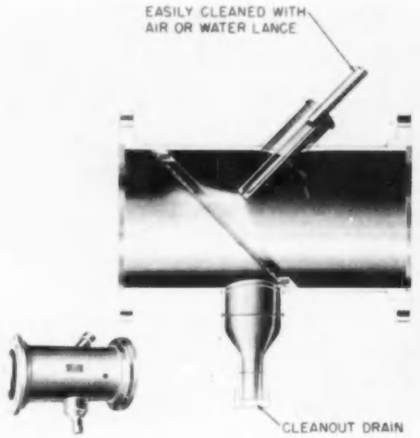

Fig. 1—The role of the strainer in assuring good pump performance is well established. Here is a design that has a draw-off cock for removing accumulated foreign matter, a valved opening downstream that permits backwashing the screen if desired

Courtesy of Leslie Co.

QUESTION:

Until recently, our steam power plants had units not exceeding 15,000 kw in size and operating pressures were all under 850 psi. Our latest addition is a 60,000 kw unit operating at 1800 psi. The boiler feed pumps are of the vertically split double casing type and are provided with a balancing device. We would like to know what stock of spare parts we should carry for these pumps?

ANSWER:

Under normal operating conditions and based on the use of the stainless steel materials now universally used for the internal parts of high pressure boiler feed pumps, the length of service before renewal of internal wearing parts is required should be of the order of at least 60,000 to 80,000 hours. Boiler feed pumps operating most of the time at or near their design point will generally have a longer life before overhaul is required. Pumps operated frequently and for long periods of time at light loads may show a lesser life between overhauls. In general, replacement of wearing parts is recommended when the initial clearances have doubled.

The number of boiler feed pumps installed and the extent to which repairs of worn parts can be carried out in the field will determine to a great extent the minimum number of spare parts which should be carried in stock at the site of the installation. In the case of this 60,000 kw unit it is presumed that two pumps are used, each for the full plant capacity and of which one pump is running and the second on standby service.

It is recommended that the following spares be carried:

1. A set of casing wearing rings.
2. A set of stage bushings.
3. A spare balancing device, made up of the rotating balancing disk and of the stationary balancing disk head.
4. One or two sets of shaft sleeves.
5. Several sets of stuffing box packing.
6. A set of bearing bushings.
7. A thrust collar and a set of thrust shoes for the thrust bearing.

It is also frequently the practice to carry a complete inner pump assembly in stock. This element can be installed in the pump when examination or tests show that the pump has become excessively worn or if it becomes accidentally damaged. In that event, the inner assembly is withdrawn from the pump and can be immediately rebuilt in the field with the parts listed above. In the meantime, the spare inner assembly is reassembled with the pump and no delay occurs in returning the pump into service.

In order to obtain the greatest service from spare parts, certain of these parts are normally furnished with undersized bores or oversize turns. For instance, the casing rings and stage bushings carried as separate spares are furnished with undersize I.D. When they are applied to a rebuilt rotor, the individual impellers should be mounted on a mandrel, trued up and miked. After this operation, the casing rings and stage bushings must be finish machined on the inside bore in such a manner as to restore the initial clearances. The latter are generally listed in the instruction book prepared by the manufacturer.

The rotating and stationary parts of the spare balancing device are furnished with oversize turn and undersize bore respectively. This is done in order to obtain the maximum life from the balancing device initially installed in the pump. When the first overhaul takes place, the original rotating balancing disk is mounted on a mandrel and trued up. It is then used in conjunction with the spare stationary balancing disk head which is finish machined in the field so as to restore the clearances given by the manufacturer.

At the time of the second overhaul, the original stationary balancing disk head can then be used in conjunction with the spare rotating balancing disk in the same manner as outlined above.

In many cases, the pump manufacturer outlines the procedure with respect to the use of spare parts in the instruction book and provides sketches of the spare parts, indicating the important dimensions.

Boiler Protection and Interlocking*

By J. L. BARKER

Oklahoma Gas & Electric Co.

Too many false interruptions in the electrical circuit which needlessly trip out boiler fuel supply or conversely too many occasions when opening the electrical circuit did not accomplish fuel shutoff led the author and his company to seek a more satisfactory protection. Their success he reports herewith.

IMPROVEMENTS in materials, design, installation and controls have made the modern power plant boiler comparable in reliability to the turbine and generator. Thus, the unit type of plant—one boiler, turbine, generator—has become operationally and economically feasible.

Automatic controls for the unit plant have been developed to a high degree. For turbines and generators, protective devices and schemes have been applied which make operation of the machines almost foolproof. Unscheduled shutdowns and failures to shut down are rarities. For boilers, much emphasis is placed on feedwater, temperature and combustion controls. In protecting boilers against fuel explosions, time honored "fail-safe" schemes are provided and occasional false shutoff of fuel is endured.

Considerations in Fuel Controls

Power plant boilers at present use the fossil fuels: coal, oil or natural gas. Although in the United States coal is predominant, and oil less common, natural gas is in general use in the Southwest area. The scheme of protection described herein has been applied to gas-fired boilers, with both induced draft and pressurized furnaces, but the same basic thinking and treatment can be applied to boilers using other fuels.

Rigidly stated, a boiler is fully protected against fuel explosion when there is no possibility of having an unignited combustible mixture of fuel and oxygen in the furnace. On this premise it would be impractical to even light off the boiler, so the criterion becomes a dangerous mixture of unignited fuel and oxygen, the danger varying with the amount of mixture relative to the size of the furnace. Boiler protection and interlocking is designed to minimize this danger.

* Presented by the AIEE Power Generation Committee for the AIEE South West District Meeting, Tulsa, Okla., March 31–April 2, 1958, as Paper No. DP 58-418.

To what extent automatic controls and interlocking should be provided is determined by circumstances, fuels, policies and varied designs. General agreement is difficult, if not impossible, because of the rapid advances in design and the trend toward centralized control. Many problems merit consideration, such as the following:

(*1*) *Loss of Flame Detectors.* Ingenious developments have been made in the design of loss of flame detectors; however, multi-burner boilers are difficult to supervise and there is question regarding the reliability and speed of response of existing methods.

(*2*) *Remote Lightoff Control.* This is not unusual. Some operating companies prefer to remotely supervise lightoff procedures by television or supervisory lights. Which is safer and more economical?

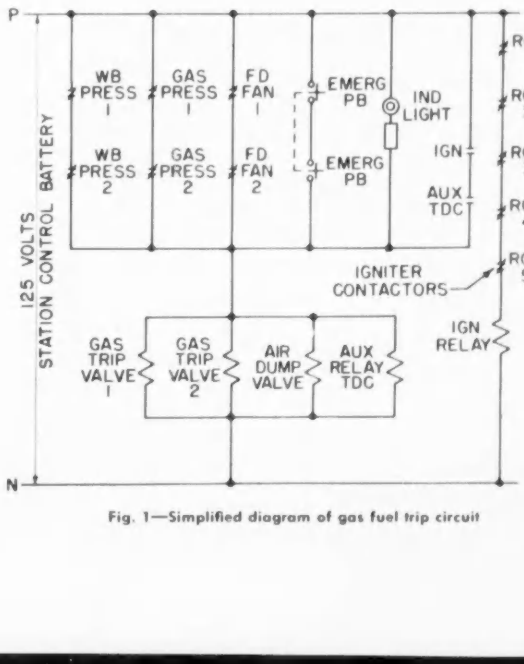

Fig. 1—Simplified diagram of gas fuel trip circuit

(3) Purge interlocking. Forced purging for a definite time before lighting off is a good safety precaution. An operator should verify sufficient flow of combustion air and low combustibles in the stack. Could he develop a feeling of security because of interlocking and overlook the essential requirements?

(4) Protective Devices. Should sufficient flow of combustion air be sensed by fan damper position, flow indicators, windbox pressure, stack combustibles or something better? There is no general agreement in this regard.

Fuel Shutoff

Several conditions may exist or occur in a boiler furnace at any time, any one of which can be dangerous enough to warrant immediate shutoff of fuel. Examples are: (1) loss of flame; (2) loss of combustion air; (3) momentary loss of fuel; (4) loss of fuel pressure.

In using a fuel such as natural gas, a prime requisite is to provide a means of shutoff which is positive and fast. The relatively slow motor-operated valve is inadequate for this function. To combine reliable fail-safe with fast operation, a spring-closed valve is used. The valve is held open by control air pressure which compresses the closing spring. For positive fuel shutoff, two valves are used in series with a vent valve between the two. The smaller vent valve is spring opened and held closed by air pressure. The control air source for the three valves is supplied through a 3-way electric solenoid-operated latchup type valve. Tripping of this air valve shuts off the air supply and vents air from the spring-operated fuel valves. To assist in venting air, an electric solenoid-operated dump valve is placed on the air manifold to the fuel valves. This dump valve is opened simultaneously with the tripping of the latchup 3-way air valve. The foregoing scheme provides positive shutoff (no gas can leak from the shutoff valves into the burner headers) and fast operation (12-in. shutoff valves close completely about 1 sec after initiation). It has been applied to the Company's large high-pressure boilers for the past 5 years.

Experience in Boiler Tripping

Until 6 years ago, the Company had followed the general practice of using a fail-safe, or normally energized, electrical circuit to initiate tripping of the fuel shutoff valve. Over the years, experience developed two objections to this practice: first, there were too many false interruptions in the electrical circuit which needlessly tripped boiler fuel; and second, there were too many occasions when opening the electrical circuit failed to accomplish boiler fuel shutoff. Fortunately, these trip failures were found in testing and scheduled shutdowns. The false tripping resulted from the usual causes: errors in maintenance of protective devices, locating control battery circuit grounds, transferring from one control circuit source to another, wiring changes during construction additions to plant, and open circuits developing in continuously energized electrical solenoids. More serious were the failures to trip. Two causes were found. First, the shutoff valve was mechanically blocked from closing. Blocking was provided in testing protective devices with the boiler in service, and at times when fuel header pressure relay switches misoperated during lightoff of a row of burners. On occasion removal of the blocking was overlooked. Second, it was found that at times the core of the continuously energized electrical solenoid on the 3-way air valve would stick in place and not release when de-energized.

In 1951, while wiring changes were being made during construction, all the boilers in a large multi-unit plant were tripped when the main circuit to the shutoff valves was inadvertently opened. All boiler shutoff valve circuits were then changed to normally de-energized, or energize to trip. Continuity of the circuit through the tripping solenoid to the protective devices was supervised by an indicating light, and the tripping source voltage was supervised by alarm.

In May 1953, the Company's largest single unit boiler was tripped several times from causes unknown. Because of this there was developed the present scheme of boiler protection.

Boiler Tripping Scheme

The present protective tripping is based on two principles. One is that each protective device which initiates closing of the fuel shutoff valves be provided in duplicate. Operation of either duplicate device sounds an alarm, but tripping is initiated only when both duplicate devices operate. The second is that each tripping device be provided in duplicate. Operation of either tripping device causes the shutoff valve to close.

A scheme requiring the operation of duplicate devices for a protective function seems to imply lack of confidence in the reliability of the protective device. Countering this, the scheme demands the quality of protective device which can be depended upon to operate in duplicate. Duplicate devices have the following advantages:

1. Periodic tests can be made with the boiler in service without blocking the shutoff valves or sacrificing protection.
2. Devices can be maintained in top operating condition without hazard of tripping off the boiler.
3. Duplicate devices can and should be located remote from each other so that they are not exposed to the same conditions of moisture, temperature and vibration.
4. Boiler control personnel are kept alert. Each protective function is alarmed by operation of either duplicate device, and these alarms are so connected that the first alarm blocks out all other protective function alarms until that alarm is acknowledged. Thus the operator knows immediately what caused the trouble and what instrumentation to check if the trouble did not cause a fuel trip. He can immediately trip the shutoff valves manually if necessary, or perhaps can change conditions to correct the trouble before losing the boiler. Duplicate devices cannot be set to operate exactly together, and may be of some operating aid when the boiler is at minimum firing rate. In any event, the operator becomes a backup for the protective device.

Quality of the protective device has been mentioned. Consider the pressure relay switch on the burner header. In lighting off a boiler, one burner is lighted, the fuel cock is fully opened, and fuel pressure is controlled by the firing valve. Fuel flow is somewhat restricted. As the second burner is lighted and its fuel cock opened, the pressure drops to about 25 per cent of its previous value. The pressure relay switch must be set to operate below this pressure (or the operator will block the relay or the shutoff valve in lighting off). Flame stability must be

positive at the pressure relay setting and the relay must positively operate at a pressure below its setting. For this function a sensitive low-range pressure relay was used with a pressure regulating valve between it and the burner header.

Duplicate tripping devices need little comment. The added expense is small and the reliability of the tripping function is improved by about a four-to-one ratio.

Fig. 1 is a simplified typical control circuit diagram for a boiler with pressurized furnace. Windbox pressure relays are used to insure positive furnace air pressure of approximately 1 in. of water. Burner header pressure of approximately 8 in. of water is required. The boiler has two forced draft fans only. When one fan motor is tripped, its outlet dampers automatically close. Should source voltage be lost to a fan motor, its circuit breaker will trip after short time delay. The manual trip push button has two contacts to minimize maintenance errors. The ignition interlock circuit prevents the shutoff valves from being latched open unless one of the five rows of burners has electric igniters energized.

The fuel shutoff control scheme has been applied to five large boilers during the last four years. In that time no boiler has tripped or failed to trip because of device malfunction. On three occasions a boiler would have tripped if protective devices had not been in duplicate. On one occasion one of the duplicate tripping devices failed to function.

Conclusions

1. Operating experience had demonstrated the reliability of a boiler fuel tripping scheme which features: (*a*) an energize to trip circuit; (*b*) duplicate protective devices, connected in parallel to alarm and in series to trip; (*c*) duplicate tripping devices, connected in parallel so that either tripping device closes the shutoff valve.

2. Considering the differences in design and operation of boilers, and the consequences of misoperations and explosions: economic, loss of availability and hazard to personnel; it is essential that the closest study and cooperation be maintained by the electrical and mechanical engineers of the operating companies, consulting engineering firms and equipment manufacturers.

Acknowledgment

The author is indebted to A. W. Walton for his suggestions in developing the protective scheme described in this paper.

Details Released on U.S. Participation in Geneva "Atoms for Peace" Exhibition

Forty-nine U.S. industrial companies plus the U.S. Atomic Energy Commission will participate in the commercial exhibition to be held next September in Geneva, Switzerland, in conjunction with the second United Nations International Atoms for Peace Conference according to the Atomic Industrial Forum, Inc., coordinators of U.S. industrial and Atomic Energy Commission participation in the exhibition.

The U.S. portion of the exhibition will occupy approximately 32,000 square feet in the recently enlarged Palais des Expositions in downtown Geneva. Comparable space will be occupied by the United Kingdom and France, and smaller exhibits will be presented by nine other countries active in atomic energy development and utilization.

The Geneva commercial exhibition, entitled the Second International Atoms for Peace Exhibition, (the first having been held in 1955 in conjunction with the first United Nations conference on atomic energy), will be the largest commercial display of atomic products and services yet held anywhere in the world.

Focal point and symbol of the American section of the exhibition will be a full-scale model of the core of an atomic power plant capable of producing 150,000 kilowatts of electric power. Surrounding the model core will be a rotunda containing an information center and displays through which the overall story of the U.S. atomic industry will be told. On either side of the rotunda will be the commercial exhibits of the 49 companies participating in the American section of the exhibition.

Highlights of the American section will be two "live" atomic reactors of the research and training type to be provided by the Atomics International Division of the North American Aviation Co. and by Aerojet-General Nucleonics, to be delivered following the exhibition to buyers in western Europe.

Other highlights of the U.S. section will be a completely equipped, mobile radioisotope laboratory, a film theater in which a continuous program of atomic energy films from both industry and government will be shown, a display of U.S. technical publications and journals, and a newly designed "master slave" robot capable of performing functions with human precision in laboratory areas too radioactive for humans to enter. The robot was designed and is being built by the Argonne National Laboratory in Lemont, near Chicago, Ill.

In addition to its role as coordinator of the U.S. portion of the Geneva Atoms for Peace Exhibition, the Atomic Industrial Forum, a non-profit organization, is handling Atomic Energy Commission participation in the U.S. section under a no-fee contract, including preparation of the conceptual outline for the thematic and integrating features of the U.S. section.

Coordinating director of the U.S. portion of the Geneva commercial exhibition is Oliver Townsend, Forum assistant executive manager. Deputy coordinating director is Daniel J. Scherer, Forum manager of public information. Supervising U.S. Atomic Energy Commission participation in the exhibition is John C. Cera, of the AEC's Office of International Conference. The Forum's coordinating work has been carried on with the cooperation of both the Atomic Energy Commission and of Molesworth Enterprises, Inc., representing 26 of the U.S. industrial participants in the exhibition.

In describing the objectives of the U.S. portion of the exhibition, Mr. Townsend said: "Our purposes are twofold. First, we wish to show those who attend the United Nations Geneva conference that the United States industry and the United States government stand together in their desire cooperatively to serve the needs and desires of the people of the world in the field of atomic energy. Second, we wish to show that, in the United States, the atom since the last United Nations conference in 1955 has moved out of the realm of dreams and hopes into the realm of practical reality."

The all too typical difficulty confronting the old, established plant was met and solved by the author's firm in supplying a treated feedwater supply for a 150,000 lb per hr, 650 psi, 750 F steam generator.

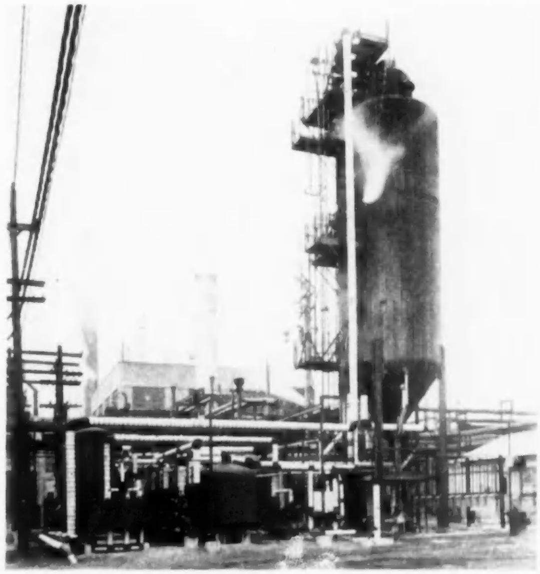

Fig. 1—The combined hot lime softener and deaerator tank prominently shown above has been added to supply treated water for a new steam generator.

By A. G. ZEIGLER

American Water Softener Co.

Combination Hot Process Softener and Deaerator Solves Space Problem and Gives Steam Savings

ONE of the last of the many bends in the Schuylkill River as it passes through Philadelphia provides the location for The Atlantic Refining Company's principal refinery. This is one of the oldest oil processing plants in the country. To supply treated feedwater at the rate of 150,000 lbs per hr for a new steam generator operating at 650 psig and 750 F, there has been installed a fully automatic hot lime zeolite softener plant.

Fig. 2—View along siding used for delivery of prefabricated tank of Fig. 1 shows pipe rack and plant obstructions through which the tank had to pass.

TABLE 1—ANALYSIS OF WATER AT REFINERY SITE

Cations	*Max.*	*Min.*	*Ave.*	*Anions*	*Max.*	*Min.*	*Ave.*
Calcium	142	53	89	Bicarbonate	151	28	58
Magnesium	74	29	57	Carbonate	0	0	0
Sodium (Calc.)	163	28	41	Hydroxide	0	0	0
Hydrogen	0	0	0	Sulfate	150	71	100
				Chloride	78	12	30

Miscellaneous	*Max.*	*Min.*	*Ave.*
Total Hardness as $CaCo_3$	216	82	146
Methylorange Alkylinity as $CaCo_3$	151	28	58
Silica as SiO_2	17.5	4.8	11.4
Iron (Total) as Fe_2O_3	3.7	0.09	1.3
pH	7.5	6.7	7.2
Dissolved Solids	500	140	260
Free Carbon Dioxide CO_2 (Calc.)	...	...	7
Langelier Index at 25° C	...	...	−1.05

Fig. 3—Cylinder-operated valves and solenoid-operated controllers have been employed in the design of the filters and zeolite units.

This water treating plant, Fig. 1, as well as its completely automatic operation, includes some interesting and unique features.

Severe Space Problem

Contrary to usual practice in installing equipment of this type, this was a "turnkey" job, the entire design, construction and installation being handled by one organization, the American Water Softener Company of Philadelphia. As is so often the case, in old established plants, the ground space was extremely limited, being but 34 ft by 50 ft, and the area almost completely surrounded by steam lines which could not be disconnected, and by other obstructions, Figs. 2, 3, 4.

The original intention was to build the softener and the deaerator as separate pieces of equipment, but this would have required more space and additional supporting structures in order to maintain the necessary head difference between the deaerator storage tank and the boiler feed pumps. By combining the two units in one tank space was saved, construction costs reduced and operating steam economies made possible. Because of the above mentioned space limitations at the plant site, it was decided to prefabricate the combined hot process softener and deaerator tank rather than build it on the spot. An added advantage in prefabrication, of course, was the opportunity to pre-test it before delivery.

The necessity for passing the completed tank through the existing steam lines and supporting structures at the refinery required a departure from the conventional in designing the tank. Consequently the raw water inlet, treated water outlet, overflow, backwash supply and return connections are all at the bottom of the tank. The problem of delivery of this tank from the manufacturing point well across the city of Philadelphia involved the use of a special tractor-trailer unit, the lifting of trolley wires and power company wires en route, to bring it alongside the Baltimore & Ohio R. R. loading dock in South Philadelphia. Two cranes, transferred the tank to a waiting P. R. R. flat car, which, with two idler cars made up a special train. Freight traffic on the P. R. R. was delayed while the B. & O. train crossed over to the refinery yard line. The entire delivery had to be scheduled to cause the least disruption of the normal heavy rail traffic in the refinery area. When the 80-ft. high tank was delivered at the site, its 9-ft. 6-in. diameter allowed but 9 in. leeway to maneuver it between steam lines and other obstructions.

Special Softener Specifications

The softener, Fig. 5, is of the thoroughfare type utilizing the entire steam requirement for heating in the deaerator compartment. The steam is then carried down to the first stage softener section to heat the raw water as it is sprayed into the tank.

In the hot process softening section an unusual backwash compartment, Fig. 5, is used, providing for the use of treated water for backwashing operations and recycling in a manner which avoids discharging backwash water to waste, thus lessening the load on the softening unit.

Specifications for this installation included the stipulation that no increase in boilerhouse operating personnel would be required for its operation. In addition, it was desired to standardize the operation of the softener unit so that there would be no fluctuation in the quality of the water due to any human element. Consequently, the entire treating, regeneration and backwashing cycles are automatically controlled. Provision is made, however, for semi-automatic operation as well. The operating cycle for the softener, based on water flow, is controlled by instruments on a panelboard in the No. 22 Boiler House, 170 ft away from the softener battery.

With the exception of the control panel, Fig. 6, the

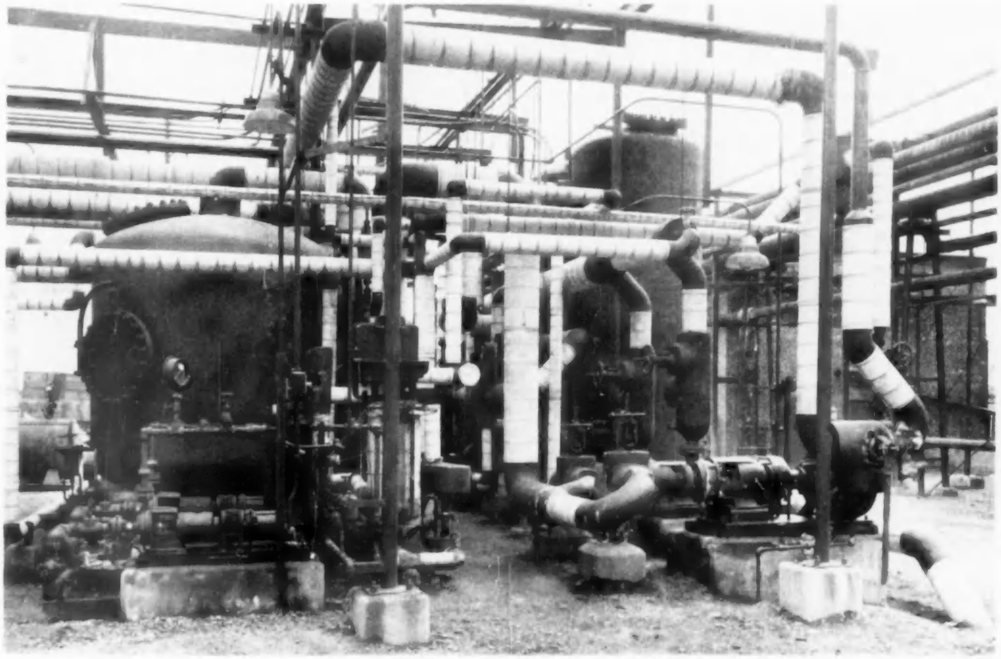

Fig. 4—Further impression of the close quarters problem can be gained from view of the access aisle between filters and zeolite tanks, brine pumps, treated water pumps and regenerant controls

complete unit is out in the open. It has to withstand exposure to temperatures normally encountered in Philadelphia which may fall as low as −11 F. Though such a temperature is not common, it is entirely possible, and below freezing temperatures are a frequent occurrence in the winter.

The Water Cycle

Raw water is supplied from either of two sources—primarily from the circulating system of a refinery cooling tower which uses river water, or, when the tower is shut down the raw water is received directly from the Schuyl-

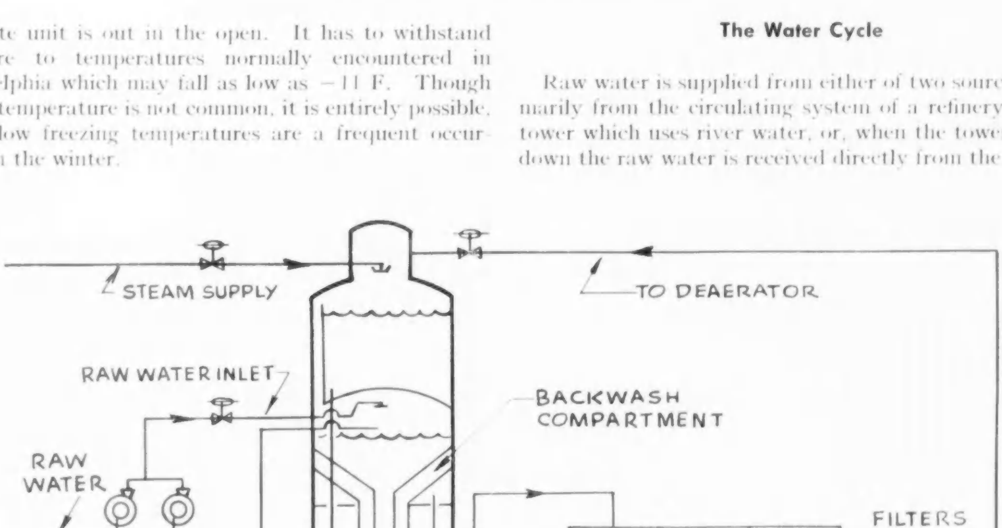

Fig. 5—Flow diagram of the automatic water treating plant at the Philadelphia refinery of the Atlantic Refining Co. Note the provision for a backwashing compartment within the deaerator that permits treated water for this service as well as for recycling without discharge to waste

kill River. The temperature of water from the cooling tower varies from 130 to 160 F, while the water direct from the river ranges from 35 to 85 F. Raw water analysis is shown in Table I.

The first stage softener is required to deliver effluent to the filters with a turbidity not exceeding 2 ppm and with a minimum oxygen content. Hardness of the zeolite treated water must be 1.0 ppm or less. The deaerator is designed to provide a 10,000 gallon reserve supply of treated and deaerated water.

The hot process softener is of the sludge blanket type. Filters are pressure type with surface washers and are designed to eliminate the need for re-wash or rinse and to thus conserve treated water. Filter beds are of graded anthracite. Hot zeolite softeners are charged with conventional type exchange resins retained on anthracite supporting beds.

In normal operation the entire water treating operation, zeolite regeneration, filter backwashing cycles are automatically controlled by the metering of the raw water flow. Even the fluffing of the zeolite beds at a predetermined period is accomplished in coordination with the main regenerating controller. Should semi-automatic control be desired, a series of alarms can indicate the necessary action to a boiler house crew member, who, at the push of a button, can set into action the required regeneration or backwashing operation.

On the panelboard in the boiler house are:

1. Reset Counters activated by impulses from the Zeolite meter integrator. Each has a contact for setting off an alarm indicating when regeneration is required.

2. A Zeolite Regeneration Controller with provision for sounding an alarm at the end of a cycle and a selector switch for determining the unit to be regenerated.

3. A Filter Backwash Controller interlocked with the Zeolite Controller and with a selector switch for selection of the unit for backwashing.

4. A Reset Counter for each zeolite softener used for fluffing upon passage of a predetermined volume. The timers receive impulses from counters associated with the zeolite meter integrator and are interlocked with the main controller.

5. Recording and integrating meters for the raw water supply.

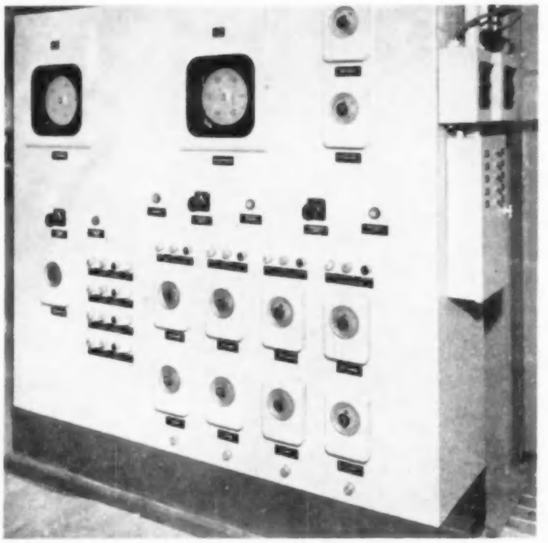

Fig. 6—Control panel, above, is the only element in the water treating plant now out-of-doors. All automatic operations are keyed to the metering of the raw flow.

Adjacent to the control panel is a concentrated array of sampling faucets to provide analysis of the water at any stage of the treating operation.

Additional instruments and controls on the softener equipment include a four-point temperature recorder, a pressure recorder, high and low level switches with alarms for the softening and deaerating compartments.

On completion of the installation, it was started up at 100 per cent of capacity and has been running continuously at or near full rated capacity ever since.

Coal Carbonization Research Lab Planned

A coal carbonization research laboratory will be erected by Island Creek Coal Company, according to an announcement today by R. E. Salvati, Island Creek president. The new laboratory will adjoin the recently expanded quality control laboratory at Holden, West Virginia, the company's operating headquarters. It is expected to be completed this year.

The coal carbonization research laboratory will enable Island Creek to provide more complete information on the coking characteristics of its coals, both when used alone and when combined with other coals. These data will assist Island Creek customers in solving problems concerned with selection, blending, and preparation of coking coals and the effect of carbonizing conditions on coke quality. It is also expected that the new laboratory will make worth while contributions to the technology of carbonization.

Facilities will include a movable-wall oven of full commercial width which will record the wall pressures developed during the coking period and provide sufficient coke of normal size for physical and chemical tests. The equipment used will follow the pattern of that designed and used by steel companies in their own laboratories. The oven will take an 800 pound sample and will produce coke by the same process as in standard size coke ovens.

The laboratory will also contain equipment to measure the shrinkage of the charge, as well as all the apparatus necessary for obtaining pertinent data on the physical and chemical properties of the coke produced.

The fuel oil supplied to the larger boiler operator in the United States always has been a residual one left over from whatever process the refinery was employing. Hence, no serious attempt has ever been made to incorporate process controls to effect an industrial fuel oil of specific properties. The residual oil buyer recognizes the "caveat emptor" mode of operation inherent in his residual purchase. Yet for his own and his equipment's welfare the large-scale oil user has sought the establishment of specifications and tests to safeguard him against a damaging shipment. Here is an excellent status report presented to the the British Institute of Fuel which we publish as an aid to understanding the various tests and sampling devices now in use in England.

*Sampling and Testing of Liquid Fuels**

By C. W. G. MARTIN†

Shell Petroleum Co., Ltd.

THIS is not strictly a Progress Review in the sense that it necessarily deals with items where discernable "progress" has been achieved since the last review of its kind. The changes which have taken place in testing procedures are quite numerous, but seldom represent a fundamental change of outlook. Moreover, the detailed amendments to the specialized techniques of oil fuel sampling and testing are perhaps not of prime interest to the average member of this Institute, bearing in mind that those so disposed can at any time study the section on new and revised methods in the Institute of Petroleum's annual volume (1)[1].

It will consequently be preferable to regard this as being more in the nature of a Status Review, which enables the subject to be treated in a more general manner.

There is a tendency to assume that the term "liquid fuels" is synonymous with petroleum, and the bulk of this review is admittedly concerned with the latter. Nevertheless, coal tar fuels are of considerable importance in some localities, and a separate short section is therefore devoted to these derivatives.

Petroleum Fuels

2.1. Sampling. Sampling of oils requires a technique entirely different from that adopted for solid fuels, but the basic purpose of the operation is unaltered, namely the need to obtain a thoroughly representative specimen of a part or of the whole of a quantity of material. Such a specimen is normally desired in order that at some time subsequently the properties of the bulk sample may be determined, but it may be that the object is to determine the extent to which there is variation among different parts of the whole quantity of liquid, either in physical or chemical properties, or in temperature.

Variations in temperature are important as they affect the specific gravity of the oil, and since the object of the investigation may well be to establish the weight of a known volume of oil (or the volume of a known weight), accurate determination of both specific gravity and temperature is essential. This operation and, similarly, the taking of a representative sample for bulk analysis, requires, ideally, the contents of a tank to be uniform.

It cannot be overemphasized that the most careful laboratory testing or quantity measurement may be rendered useless by inadequate sampling. However, the taking of a truly representative sample may be difficult. One example of this is at the petroleum refinery itself, where however close the controls, there will occasionally be minor differences (if only in temperature) in products manufactured over a 24-hour day. Even if the quality of the product is unaffected, no oil can be considered as uniform, from the measurement point of view, unless it is at the same temperature throughout.

Fuel oils present their own individual problems. Fortunately the precautions relating to some of the more volatile products, such as motor gasoline (where the possible loss of the lighter fractions by evaporation has to be guarded against), do not apply, but on the other hand there is the fact that some fuel oils are pumped at relatively high temperatures, and gradually cool off in storage tanks. The most obvious way of ensuring uniformity of the contents would be to pump the fuel round rapidly, but the high viscosity which some fuel oils reach as the temperature is lowered may make this impracticable unless the tank is maintained at a temperature higher than convenient or economical.

The system adopted to overcome the difficulty is to take a number of samples, from different places in the tank, spaced so as to ensure that the whole volume is

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[1] Numbers in parentheses refer to similarly numbered entries in the list of References at the end of article.

adequately represented. It is obviously inconvenient to take numerous samples at varying levels throughout a tank, and in practice it is considered that a true average or representative sample is produced if, after preliminary examination has shown that the contents are substantially homogeneous and the cross-section of the tank is uniform, equal portions are taken from levels at one-sixth, one-half and five-sixths of the depth of the liquid below the top surface.

This, of course is "batch" sampling; sometimes it becomes necessary to take a continuous sample, as in the case of oil flowing along a pipeline. This can be done by the insertion of sampling cocks to draw off small quantities more or less continuously during the delivery.

Fuller details of procedure are given in the Institute of Petroleum's book of test methods under the heading of "Sampling Petroleum and Petroleum Products" (2).

2.2. Testing Methods and Their Interpretation. The testing of liquid fuels (as of many other products) has evolved into a series of especially tailored methods. A few of these can be regarded as of fundamental importance, but mostly they are purely empirical tests designed essentially to give the answer to a particular practical inquiry, real or implied.

To explain this a little more fully, let us take the tests for sulphur content and flash point. The former gives us the measure of a fundamental characteristic of the fuel, the percentage of a particular element. By what method of test this percentage is determined is virtually unimportant; the result is a factual one, and should not vary by more than the experimental error of the determination itself.

The test for flash point, however, comes into a very different category. There are several types of instrument, designed by different people, with variations in the dimensions of the apparatus, the quantity of oil used, the rate of temperature rise and so on. The test may be conducted in a virtually "closed" chamber, or the surface of the oil may be quite open to the air. In other words, flash point is a test devised by oil technologists to give them guidance on a particular feature—the possible fire hazard appertaining to the use of such oils. Its results are indicative, not absolute; they cannot be conclusive, since the interpretation of the figure obtained as a test result can be a matter of individual opinion or of personal experience.

Even when a test, in some form or another, has been in use for a generation, such as the determination of "asphaltene" content, it is possible to find "experts" disagreeing on its practical significance, i.e., to what extent it affects the burning properties of the fuel.

Another point worth consideration is the degree of precision obtainable in the actual laboratory tests. However carefully an experiment may be carried out, whether in determining a fundamental property or in executing an empirical test routine, small uncontrolled variations in conditions are unavoidable. In consequence, small variations are obtained in repeat determinations of a test. The *repeatability* of sulphur determinations by the quartz tube method is estimated as 0.10 per cent when the result obtained is below 1 per cent. This means that an operator should get successive results within this bracket of 0.10 per cent and such would be accepted as mutually confirmatory. The *reproducibility* of the same test conducted by different operators in different laboratories is also regarded as being 0.10 per cent within the same sulphur range. At sulphur contents above 1 per cent the reproducibility limits are reckoned to be slightly greater than those accepted for repeatability.

Apart from these terms the expression *confidence limits* is sometimes used. This represents the range within which 95 per cent of the repeat results are statistically expected to fall. In the example taken, a result of 1 per cent would command "95 per cent confidence" that the true value would not be below 0.93 per cent nor above 1.07 per cent.

In the case of viscosity, fuel oils of over 100 sec Redwood I at 100 F are considered to have a repeatability of 1 per cent and a reproducibility of 2 per cent about a mean figure. Though experienced operators can often get well within such tolerances, the accepted degree of repeatability should not be overlooked. It is therefore not reasonable to expect analysts to report viscosities of heavy fuel oils within 1 sec Redwood, any more than sulphur contents should be reported, in a routine test, to a third place of decimals, or flash point to a fraction of a degree of temperature. The improvement in customer awareness of this, even in some of the more literally minded countries, has been very marked.

2.3. Specifications. For all that has been written on this problem of interpretation, there is a reasonable measure of agreement amongst standardization bodies as to the tests most suitable for expressing the required characteristics of a fuel oil in the form of a specification.

The actual test figures from a laboratory examination of a particular sample go to make up an "inspection" or "analysis," but if, using these figures as a guide, a customer prepares a set of limiting values to stipulate the limits to which he is prepared to accept future supplies, this then constitutes a "specification." These tests may be of a chemical, physical or mechanical nature, and although, as mentioned, many are empirical, they have been standardized as closely as possible by the petroleum industry, and, if the prescribed technique is closely adhered to, the results are normally repeatable within the quite narrow limits already discussed.

The specification is thus a means of controlling quality, and the tests selected should be those which will indicate the behavior of the fuel under the known or expected conditions of transportation, storage and use (3).

Numerous examples could be cited, but perhaps the most appropriate is B.S. 2869:1957 issued recently by the British Standards Institution to replace B.S. 209 and 742, both dated 1947.

This standard covers engine fuels (with which this review is not greatly concerned), domestic fuels and marine and industrial fuels. It will be interesting to examine these specifications, to note the test methods which are invoked and to consider the implications and interpretation of the limits which are set.

2.3.1. Domestic Fuel Oils. British Standard 2869: 1957 (4) includes a section dealing with fuels for those small automatic burners used for domestic and other purposes, which require a distillate fuel for best results. Such fuels, known as Class D, require no preheating in storage or for use in temperate climates, and as a generalization, bear some resemblance to Class A fuels (for high-speed, automotive-type, diesel engines) except that they do not of course require compliance with those tests, such

as ignition quality, which are of importance only in the case of fuels for compression ignition engines.

Detailed requirements for Class D fuels are

Viscosity, kinematic, at 100 F	Max 7.5 centistokes
Carbon residue (Conradson), percentage by weight	Max 0.2
Flash point (Pensky-Martens, closed cup)	Min 130 F
Water, percentage by volume	Max 0.25
Sediment, percentage by weight	Max 0.05
Ash, percentage by weight	Max 0.01
Sulphur, percentage by weight	Max 2.0

Footnotes to the specification draw attention to the following

(1) The viscosity limit is roughly equivalent to a maximum of 45 sec Redwood I at 100 F (other conversions are also given).

(2) It is recognized that there are circumstances in which a minimum flash point of 150 F may be required (e.g., local storage regulations).

(3) It is recognized that some automatic burners will operate quite satisfactorily on fuels heavier than Class D, for example those in the marine diesel fuel category.

2.3.2. Industrial and Marine Fuels. Since many of the test methods used in the domestic fuel specification apply equally to the other classes, it will save repetition to quote the industrial and marine fuel specifications at this point

	Class E	*Class F*	*Class G*	*Class H*
Viscosity, kinematic at 122 F	Max 36 c.s.	Max 125 c.s.	Max 370 c.s.	Max 690 c.s.
Flash point PM closed cup	Min 150 F	Min 150 F	Min 150 F	Min 150 F
Water, percentage by vol	Max 0.5	Max 1.0	Max 1.0	Max 1.5
Sediment, percentage by wt	Max 0.15	Max 0.25	Max 0.25	Max 0.25

It is considered a technical advantage to specify viscosity in kinematic units, but it is nevertheless realized that the conventional viscometers are still widely used, and although the following table must not be regarded as a means of conversion from Redwood viscosities to kinematic viscosities, nor from one temperature to another, it is of interest to relate the kinematic limits to those which are, at present, the more widely used in commerce

36 Centistokes at 122 F = (approx.) 250 seconds Redwood I at 100 F
125 Centistokes at 122 F = (approx.) 1000 seconds Redwood I at 100 F
370 Centistokes at 122 F = (approx.) 3500 seconds Redwood I at 100 F
690 Centistokes at 122 F = (approx.) 7000 seconds Redwood I at 100 F

The Standard gives comparable data for other instruments, such as Saybolt (Universal and Furol) and Engler viscometers, for the convenience of those to whom these are at present more familiar than kinematic units.

2.4. Analytical Tests and their Significance. It now remains to examine the seven analytical tests which go to make up these specifications, and to consider also those which, while in common use in the petroleum industry, have failed to gain inclusion. All the methods here discussed are described in Institute of Petroleum and ASTM publications, (5, 6), and accordingly no detailed account of testing techniques will be given here.

2.4.1. Viscosity. The most important test applied to fuel oils is the determination of viscosity and, quite frequently, this single characteristic (e.g., "200 sec") is adequate for normal purposes as a description of the grade. This is especially so when the reference is to viscosity determined by one of the conventional types of viscometer such as Redwood, Saybolt or Engler, where the viscosity is measured according to the time of outflow of a stipulated quantity of oil at a specified temperature under standard conditions.

Nevertheless, it will be observed that British Standard 2869:1957 calls for viscosity to be determined in kinematic units, (7), as being technically more accurate and more rapidly carried out.

Viscosity is the property of a fluid which determines its resistance to shear or flow. Whether such flow is along a pipeline or whether it is to the nozzle of a burner unit, there is an optimum range of viscosity at which the operation is most conveniently or efficiently carried out. Consequently, since the viscosity of petroleum fuels increases as the temperature is lowered (80 sec Redwood I at 200 F might represent 8000 sec at 50 F), it is standard practice to heat then to bring the viscosity to the desired figure. Ideally, a viscosity temperature curve would appear to be indicated, but in practice the slope of such curves is fairly constant, especially at the more elevated temperatures, and for normal purposes one viscosity at a standard control temperature is adequate. To avoid inaccuracies in testing at low temperatures, it is usual to set such control at well above normal ambient temperatures, and it will be seen that for the heavier fuels, the British Standard is specified at 122 F (50 C).

2.4.2. Carbon Residue (Conradson). This test broadly compares the relative tendency of fuels to form carbonaceous deposits under bad combustion conditions. It is important to realize that neither the Conradson nor the Ramsbottom test (different in detail but having the same basic objective) predicts the amount of coke which will form on injector nozzles. For a distillate fuel, such as Class D, the Conradson carbon percentage must be almost negligible; for the heavier "residual" fuels it almost ceases to have any importance and is consequently not specified for classes E to H.

2.4.3. Asphaltenes. This is one of the empirical tests which do not even appear in the specifications at all. Though completely different in technique from the Conradson Test (the latter gives the percentage of "carbon" left after burning the oil in a limited supply of air, while the asphaltenes are benzene-soluble bodies of high C/H ratio which are precipitated from the fuel oil when a large excess of volatile spirit is added) the two determinations sometimes move in parallel. The current method of test (I.P. 143/57) uses *n*-heptane instead of the petroleum 60/80° spirit in use for so many years. A "nil" asphaltene content represents a distillate fuel. The heaviest fuel oils may have 15 per cent or so asphaltenes or Conradson carbon residue, but this merely indicates that they contain asphaltic residue which, however, in the proper conditions and equipment, will burn with complete satisfaction. For the purpose of interpreting the U. K. Customs and Excise Act, 1952, the terms "asphaltenes" and "hard asphalt" are considered to be synonymous.

2.4.4. Flash Point. Usually the flash point of fuel oils is determined with the cup "closed," that is to say a shutter in the lid of the oil container is only momentarily opened to allow a flame to pass across it to see if the fuel "flashes." The lowest temperature at which it forms

this inflammable mixture with air under rigidly standardized conditions is defined as the closed flash point. As already explained, there is nothing absolute about this figure. In many countries it is obligatory for fuel oils to have a closed flash point of 150 F or over to comply with storage, insurance and/or transport regulations, and ever since 1902 marine fuel oils have similarly had to meet this requirement.

2.4.5. Sediment and Water. Both water and sediment are undesirable if present in quantity, and it is usual to specify a limiting percentage which will be accepted. Most fuel oils can hold in suspension a certain amount of water, the quantity depending upon the specific gravity and viscosity of the fuel and, sometimes, on the crude oil from which it has originated. Sediment may comprise sand, rust, fibrous or carbonaceous matter which, in excess, may clog filters or interfere with ease of atomization and combustion.

Water content is normally determined by a distillation method, sediment being estimated separately as being the quantity of insoluble material which can be filtered off when the oil is washed with certain solvents. Sometimes the total sediment and water is determined together by a centrifuge test, but this method has limitations and the results are not strictly accurate.

2.4.6. Ash. Ash is the residue remaining after all consumable portions of the oil are completely burnt away. Depending on their source, crude oils may contain varying amounts of aluminum, calcium, iron, magnesium, nickel, silicon, sodium and vanadium; in addition there may be traces of chromium, lead and titanium. Many of these materials may be introduced or increased by contamination of the fuel with tank scale, road dust or sea water. Some can be removed by filtration or centrifuging, but others, such as, particularly, vanadium or nickel, are present in an oil-soluble form and cannot be removed by any economic process. For distillate fuels such as B.S.I. Class D the ash must be negligible; for boiler fuels it may be up to about 0.1 per cent or so, though generally it is well below this. For certain specialized applications the nature and amount of ash are important, and it may then be necessary to specify a limiting figure. Generally, however, it would not be necessary to prescribe a limit for fuels of classes E to H.

In recent years spectro-photometric methods for ash determination have come into use, but it is seldom that these are used on fuel oils.

2.4.7. Sulphur. Crude oils vary so greatly in respect of sulphur content that to specify a limit for most of the heavier fuel oils would simply mean greatly increased cost. In certain industries, such as steel, the sulphur content of the fuel must be fairly low, and this may involve special segregation and transportation, as the desulphurization methods at present in use are not economically applicable to residual fuel oils, although the newly developed "H-Oil" process (8) may offer some promise in this direction, should its economic evaluation prove satisfactory.

A number of quite common routine tests still remain to be mentioned, although they have not been included, for one reason or another, in the standard specification of the British Standards Institution. This review would not, however, be complete without some mention of such characteristics as calorific value, specific gravity, pour point and one or two other tests.

2.4.8. Calorific Value. This factor is not controllable in the manufacture of the fuel, except in a secondary manner by the specification of other characteristics. In a sense, moreover, the calorific value of a petroleum fuel oil is of less importance than in the case of solid fuels since the variation between high and low grades is comparatively slight. Whereas coal may have a calorific value of from about 10,000 to 15,000 Btu per lb (5550 to 8300 calories per gram), almost all petroleum fuel oils have a gross calorific value between 18,000 and 19,000 Btu (10,000 to 10,550 calories per gram) and even the lightest gas oils do not greatly exceed 19,600 Btu/lb or say 10,900 calories per gram.

The calorific value is determined by actually burning a small quantity of oil in oxygen and by accurately calculating the amount of heat units produced, applying suitable corrections for loss of heat by radiation. It is also possible to effect a calculation of the calorific value from the ultimate analysis of the fuel, that is to say, the actual proportions of carbon, hydrogen, sulphur, etc., since it is known what quantity of heat is liberated when unit quantities of each of these elements are completely burnt. However, the determination of the percentage composition in terms of the elements present is much more difficult than ascertaining the calorific value experimentally by means of the bomb calorimeter, and may be much less accurate.

The hydrogen in a fuel, when burnt, produces, in the first place, steam, but the calorific value as determined experimentally or by formula allows for the condensation of this to form water. A deduction must, therefore, be made from this "gross" calorific value to correct for the latent heat of this water. This lower result is the "net" calorific value, and differs from the gross figure by about 54 calories for each per cent by weight of hydrogen in the fuel—say about 600 calories per gram, or 1080 Btu per lb.

2.4.9. Pour Point and "Pumpability." The pour point of an oil is the temperature at which, under defined conditions of test, the oil will just flow under its own weight. The test has, however, many practical objections since, in view of the small quantity on which the test must necessarily be conducted and the artificial conditions thereby introduced, the result may have little bearing upon practical operations. For example, the test does not indicate what happens when an oil has a considerable head of pressure behind it such as when gravitating from a receptacle or being pumped along a line. Moreover, it does not reproduce static conditions of storage, and the fact that a quantity of about 30 ml solidifies in a small bottle where a considerable portion of the oil is in contact with the surface, does not mean that the same oil in bulk in a large storage tank will solidify at the same temperature, since the insulating effect of the wax skin which is formed may actually keep the core comparatively warm and still fluid.

The previous treatment of an oil has a very important bearing upon the pour point. If the oil has been heated shortly before the test is carried out, the result may be very different from what it would have been had no such treatment taken place. With fuel oil such heat treatment is quite commonplace, and particular precautions usually have to be taken to ensure that the pour point determination is not affected thereby.

Since for reasons such as these many fuel oils can be pumped at temperatures well below their pour point,

(9), attempts are continually being made to devise some practical test which will reproduce the conditions of "pumpability," or in some other way correlate the laboratory pour point with bulk behavior at low temperatures.

Bearing in mind also the wide range of climatic conditions under which fuel oils may be used, it will readily be understood why the B.S.I. considers it undesirable to attempt to specify limiting values for pour point.

2.4.10. Specific Gravity. Contrary to the belief widely held at one time, the specific gravity in itself has no technical significance, though with fuels of one particular origin it is true that an increase in specific gravity may indicate an increase in viscosity. It is not the sort of test properly found in a B.S.I. specification.

2.4.11. Stability. Apart from the foregoing general tests, it sometimes happens that a buyer will impose certain other conditions when a fuel is required for some specific purpose, e.g., for naval use, where it is important to ensure that when heated the fuel oil will not throw down a deposit which will clog strainers, preheaters or burners. Various heater fouling tests are in existence which give a visual or gravimetric means of distinguishing relative "stability" of fuels, alone or in mixtures. True stability is best measured by a hot filtration test.

2.4.12. Elementary Analysis. Sometimes, in connection with certain problems, it is required to calculate the amount of air theoretically necessary for complete combustion, and it then becomes necessary to know the actual composition of a fuel in terms of its proportion by weight of its elements, e.g., hydrogen, carbon, oxygen, sulphur, etc. This is not normally required in a general specification, since the range of variation (from about 11 to 13.5 per cent in the case of hydrogen) is narrow.

2.5. The Assessment of Quality. It is evident that there is no absolute definition of that elusive term "quality" in a fuel oil (10). Theoretically the main necessity is a high calorific value, but, as has been explained, this is already determined by other factors. The type of burner to be used, and the degree of oil preheating which is possible in storage or before burning, will determine the viscosity requirement, and it is eminently reasonable to require a low water and sediment content. Beyond these, and a flash point as required by regulations, the ordinary user needs few guarantees unless the application is a specialized one, in which case a limit may be desirable in respect of sulphur, ash, or some other characteristic. Each additional control test, however, and every attempt to segregate special components for particular purposes, adds to the cost of production and it is therefore important to limit the call for special testing to those cases where there is need for more information than is normally available from the routine inspection tests.

Coal Tar Fuels

Dependent upon the extent to which crude coal tar is distilled, and the degree to which blending with light creosote fractions is carried out, a wide range of liquid fuels can be prepared. As with petroleum fuels, many of these must be heated to bring them to a viscosity suitable for efficient atomization. This is usually regarded as not more than 100 sec Redwood I (about 24 centistokes) and a scale of approximately equiviscous temperatures has formed the basis of the nomenclature used in the United Kingdom. Coal Tar Fuel 200, for example, would indicate that 200 F is regarded as the temperature at which it is in a condition suitable for atomization and combustion.

3.1. Specifications. The British Standards Institution has published a specification on Coal Tar Fuels, B.S. 1469:1948, covering two grades of distillate oils (creosote) and a blended fuel originally designed to have characteristics similar to those of 950 sec petroleum fuel oil. This fuel is known as C.T.F. 200 (Creosote Pitch Mixture). In addition to the British Standard the booklet *Coal Tar Fuels* published by the Association of Tar Distillers gives further specifications for C.T.F. 250, C.T.F. 300 and C.T.F. 400. The essential portions of these specifications are summarized below (11)

	C.R.F. 50	C.T.F. 100	C.T.F. 200
Viscosity Redwood I			
At 100 F	Max 60 sec	Max 100 sec	Min 1000 sec; Max 1500 sec
At 200 F			Max 100 sec
Liquidity, completely liquid at	32 F	90 F	
Flash point (closed)	Min 150 F	Min 150 F	Min 150 F
Calorific value (gross) Btu/lb	Min 16,500	Min 16,500	Min 16,250
Water content, percentage	Max 1	Max 1	Max 1
Ash, percentage	Max 0.05	Max 0.05	Max 0.25
	C.T.F. 250	C.T.F. 300	C.T.F. 400
Viscosity Redwood I			
At 160 F	Max 1500 sec		
At 250 F	Max 100 sec		
At 300 F		Max 100 sec	
At 400 F			Max 100 sec
Flash point (closed)	Min 150 F	Min 150 F	Min 150 F
Calorific value (gross) Btu/lb	Min 16,000	Min 16,000	Min 16,000
Ash, percentage	Max 0.3	Max 0.3	Max 0.75

The sulphur content is normally required to be below 1 per cent.

In addition to the foregoing, the British Standard stipulates maxima for matter insoluble in toluene. For C.T.F. 50, C.T.F. 100 and C.T.F. 200 the figures are 0.5 per cent, 0.5 per cent and 15 per cent respectively. This test provides a control on the possible admixture of residuals in the distillate fuels and at the same time minimizes the likelihood of heterogeneity on storage of C.T.F. 200. It should be understood that the material insoluble in toluene is normally uniformly dispersed or dissolved in the fuel and it is only dilution with the light hydrocarbon which causes the separation.

The test for complete "liquidity" is peculiar to coal tar fuels, indicating whether they are fluid and completely free from separated soluble solid matter when held at the temperature of the test.

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Abstracts from the Technical Press—Abroad and Domestic

(Drawn from the monthly Technical Bulletin International Combustion, Ltd., London, W.C. 1)

Fuels: Sources, Properties and Preparation

The Oxygen in Coal—How It Affects Coking Properties. Anon. *C.S.I.R.O.* 1958, **3,** (Feb.) 14–5.

Studies of the oxygen content of Australian bituminous and brown coal are reported. In coal with a C content of 80 to 90 per cent most of the oxygen is present in the form of phenolic groups, in some cases over 70 per cent. Acidity decreases with increasing C content. In carbonisation tests the main loss of acidity occurred between 400 and 500 C. Work on ascertaining the nature of the oxygen in the form of non-acidic groups is in progress. When treating brown coal with alkalis at 180 C, materials soluble in organic solvents and forming highly swollen coke on crucible coking tests were produced.

The Swelling Power of Coal During Low Temperature Carbonisation. R. M. E. Diamant. *Fuel* 1958, **37,** (Apr.) 187–90.

A swelling meter is described and observations made on its use are discussed, especially the relation of temperature range in which swelling takes place and the production of fine and course pores in the coke.

Mechanical Handling

Materials Handling. R. W. Wessen. *Ind. Engng. Chem.* 1958, **50,** Pt II (Mar.) 474–7.

The annual review of literature published during 1957.

Feeding Hydraulic Transport System. Anon. *Min. J.* 1958, **250** (Apr. 4) 383.

The feeder developed by the Central Engineering Establishment of the N.C.B. for the hydraulic transportation of coal is described and its working sequence explained.

Feeding Coal into Hydraulic Transport Systems. Anon. *Colliery Guard.* 1958, **196** (Mar. 27) 409.

A horizontal lock hopper feeder developed by the N.C.B. is described, which is intended mainly for installation underground.

A Large Coal-Handling Plant with Extensive Application of Fluidrive. Anon. *Engng. Boil. Ho. Rev.* 1958, **73** (Apr.) 116–8.

The plant at Castle Donington Power Station with a capacity of 960 t/h is described in detail.

Heat: Cycles and Transmission

Heat Transfer. E. R. G. Eckert, J. P. Hartnett and T. F. Irvine. *Ind. Engng. Chem.* 1958, **50** Pt II (Mar.) 543–54.

The annual review of literature published during 1957 with subheadings of conduction, channel flow, boundary layer flow, flow with separate regions, transfer mechanism, natural convection, transpiration and transfer cooling, change of phase, radiation, liquid metals, measurement techniques, and heat transfer applications.

Calculation of Heat Transfer to Water and Steam near the Critical Point. Z. L. Miropolskii and M. E. Shitsman. *Energomashinostroenie* 1958, **4** (Jan.) 8–11. (*In Russian.*)

Existing methods of calculating heat transfer coefficients together with the results of experimental investigation of the coefficients of heat transfer to non-boiling water and superheated steam around the critical range of pressures and temperatures are compared and discussed. A nomogram and rating formula are included.

From *C.E.G.B. Digest* 1958, **10** (Apr. 26) 1027.

Heat Transfer by Radiation between Plane and Curved Surfaces. R. Pich. *Energie* 1958, **10** (Mar.) 83–9. (*In German.*)

In this first part, equations are developed for calculating heat exchange by radiation between surfaces without interfering absorbing media. The equations for heat exchange with interfering absorbing gases or dust suspensions is in the second part.

Steam Generation and Power Production

Fluid Dynamics. A. K. Oppenheim, C. L. Coldren, L. M. Grossman and C. V. Sterling. *Ind. Engng. Chem.* 1958, **50** Pt II (Mar.) 525–42.

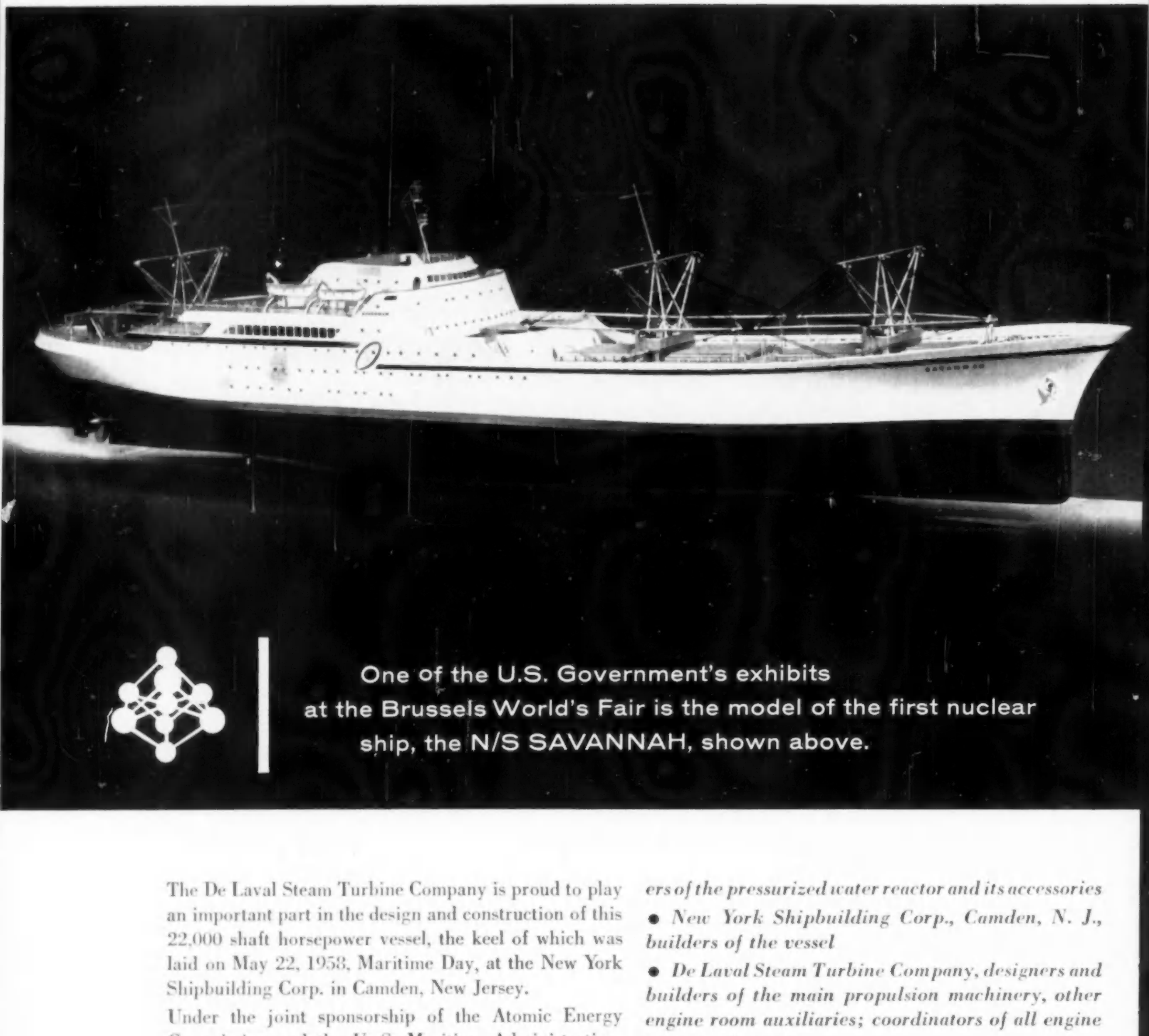
The annual review of literature published during 1957.

Flow of Fluids. M. Weintraub. *Ind. Engng. Chem.* 1958, **50** Pt II (Mar.) 447–52.

The annual review of literature published during 1957 with subheadings of single phase flow, flow through porous media, multi-phase flow, and mechanical design.

(*Continued on page 59*)

Creative Engineering by DE LAVAL



The De Laval Steam Turbine Company is proud to play an important part in the design and construction of this 22,000 shaft horsepower vessel, the keel of which was laid on May 22, 1958, Maritime Day, at the New York Shipbuilding Corp. in Camden, New Jersey.

Under the joint sponsorship of the Atomic Energy Commission and the U. S. Maritime Administration, major contributions to the design and construction of the vessel and its machinery are being made by:

- ***George G. Sharp, Inc., naval architects, designers of the vessel***
- ***Babcock & Wilcox Company, designers and builders of the pressurized water reactor and its accessories***
- ***New York Shipbuilding Corp., Camden, N. J., builders of the vessel***
- ***De Laval Steam Turbine Company, designers and builders of the main propulsion machinery, other engine room auxiliaries; coordinators of all engine room equipment.***

We are particularly happy to serve in connection with this project of international importance. De Laval has often performed other important services as complete engineering coordinators, and is fully prepared to undertake similar assignments.

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886 Nottingham Way, Trenton 2, New Jersey

Some Recent Developments in Steam Generating Practice. W. C. Carter. *J. Inst. Fuel* 1958, **31** (Apr.) 166–73.

This review deals with some aspects of the development of boiler design, such as: (1) Elimination of refractories in furnace construction and the introduction of tangent tube walls; (2) boilers for dual firing with coal or oil; (3) boilers for boiler-turbine unit operation; (4) boilers for 2-shift operation; (5) boilers with twin furnaces; (6) prefabrication of boiler walls; (7) boiler suspension; (8) flue gas recirculation.

Method of Operating a Boiler for Generating or Superheating Steam or Vapors. Combustion Engineering Inc. *British Patent* 792,682 U.S.A., 9th November, 1954.

A boiler is described in which the water is evaporated and/or steam superheated in coils immersed in a bed of fluidised catalytic oxidation promoters. The fuel is injected together with air through a perforated pipe in the bottom of the bed and additional secondary and fluidising air through a perforated bedplate. The oxidation of the fuel takes place within or without the inflammability range of the fuel, so that a temperature of 1200 to 1800 F is maintained in the neighborhood of the first contact of fuel and catalyst and a temperature differential of 100 F and more between the bottom and the top of the bed.

Furnaces and Combustion

Improved Combustion in Coal-fired Small Boilers. W. Haselau. *Betrieb u. Techn Überw.* 1958, **3** (Mar.) 51–2. (In German.)

The recent invention of a refractory arch over the bridge wall of fire tube boilers is at present under tests in several boilers. This arch forces the colder combustion gases flowing near the top of the fire tube to pass through the hole between the arch and bridge and there to mix with the other gases, the temperature at this point is so high that any unburnt hydrocarbons are reignited and stratification effectively avoided. It is also possible to include baffles to give the gases a whirling motion at this point and thus to increase their turbulence. It is hoped by this means to reduce soot formation and excess air requirements and to increase the CO_2 content of the flue gases. The additional draught required is only 3–5 mm w.g.

Studies on Combustion of Pulverized Coal. Pt, I. Physico-Chemical Aspects. B. Ghosh. *J. Sci. Industr. Res.* 1957, **16B,** (Oct.) 161–9.

Physico-chemical aspects of the combustion of pulverized coal are discussed with reference to the formation of stable flames. From theoretical considerations equations are developed to correlate the burner mouth velocity at stable flame positions with different variables like coal concentration, particle size, temperature of the flame and the furnace walls, partial pressure of oxygen in the suspension, etc. Mathematical analysis also emphasizes the difference between the modes of propagation of gas flames and pulverized coal flames. While stability of a gas flame depends on heat transfer processes localized near the flame front, the stability of a pulverized coal flame is determined by long range heat transfer by radiation.

From *Fuel Abstracts* 1958, **23** (Apr.) 3528.

Temperature Conditions with Horizontal Steam-Generating Tubes at Extra High Pressures. V. G. Chakrygin and V. A. Lokshin. *Teploenergetika* 1957, **4** (Sept.) 58–63. (*In Russian.*)

Results are given of an experimental investigation of temperature conditions in horizontal steam generating tubes at pressures of 180–220 atm and heat flows up to 1×10^6 kcal sq mh. Temperature features in the tubes under these conditions, mainly in the boiling region, are discussed. It is established that at extra high pressures a temperature divergence occurs along the perimeter of a horizontal heated tube owing to flow lamination, both during the movement of the boiling fluid and of water which has not reached the boiling stage. In high pressure once-through boilers with horizontal tubing, pellicular conditions of boiling may deleteriously afflict operation. Measures for avoiding breakdown in the normal temperature routine are indicated.

From *Fuel Abstracts* 1958, **23** (Apr.) 3410.

Studies on Combustion of Pulverized Coal. Pt II. Combustion within a Furnace. N. K. Ray, D. Basu and B. Ghosh. *J. Sci. Industr. Res.* 1957, **16B** (Oct.) 170–4.

The energy necessary for the ignition of pulverized coal is obtained partly from radiation and partly from exothermic chemical reaction between coal and oxygen. The nature of coal, particle size, coal to air ratio, etc., also influence the ignition process and determine the character of the flame. The present work deals with the study of the influence of these factors on the combustion process. The experimental results agree qualitatively with theoretical analysis of the ignition process.

From *Fuel Abstracts* 1958, **23** (Apr.) 3529.

(*Continued on page 61*)

Water-Side Corrosion and Water Treatment

Deaeration for the Small Plant. R. F. Schaub. *Power* 1958, **102** (Apr.) 118–9.

After explaining the reasons for installing feedwater deaerators even in very small boiler plants, details of design of a deaerator for duty with a boiler generating 3000 lb/h in summer and 7500 lb/h in winter at 100 psi are given.

Breakthrough in Condensate Purification. V. J. Calise. *Combustion* 1958, **29** (Mar.) 40–5.

Reasons are given for advocating the installation of filters and mixed bed demineralisers in the condensate circuit of high pressure sub- and supercritical boilers, especially those of the once-through type. This additional purification unit would remove impurities and dissolved solids introduced with the make-up water by corrosion, by fly ash contamination, and by leakage of cooling water.

Gas-Side Corrosion and Deposits

Accelerated High Temperature Oxidation due to Vanadium Pentoxide. K. Sachs. *Metallurgia* 1958, **57** (Apr.) 167–73.

This second part of this review deals with the mechanism of vanadium pentoxide attack and secondary effects of vanadium pentoxide.

Controlling Corrosion in Coal-Chemical Plants. C. P. Larrabee and W. L. Mathay. *Corrosion* 1958, **14** (Apr.) 37–40.

It is recommended to use stainless steels containing 12 per cent or more of Cr for coal bunkers, chutes, and the hoppers of larry cars, and stainless steels (18 per cent Cr 9 per cent Ni) for those parts of the chemical plant (coolers, saturators, tar stills, rectifiers) where corrosion tests have shown that their application would be economically justified.

Plant Growth on Fly Ash. R. Holliday, D. R. Hodgson, W. N. Townsend, and J. W. Wood. *Nature* 1958, **181** (Apr. 12) 1079–80.

Investigations at Leeds University into reclamation of land covered with fly ash have led to the establishment of a classification of crops into three main groups on the basis of their ash tolerance (tolerant, moderately tolerant, sensitive). It has also been found that the boron content in the ash is the primary toxic constituent.

Improved Sampling Equipment for Solids in Flue Gases. P. G. W. Hawksley, S. Badzioch, and J. H. Blackett. *J. Inst. Fuel* 1958, **31** (Apr.) 147–60.

The sampling equipment developed by C.B.U.R.A. is suitable for the separate determination of grit, dust, and smoke in flue gase and consists of a $1\frac{1}{2}$ in. cyclone inserted into the gas stream at the end of a probe. The cyclone is also used as a flowmeter. At sampling rates above 5 cu ft/min all particles above 5–10 μ are collected; particles above 76 μ (grit) are separated by sieving, and smoke particles below 10 μ are separated in a glass-wool filter. Methods of use and some practical points arising from these are discussed. The first appendix gives details of construction of the equipment, and the second appendix the equations for calculating flue gas velocity, flow rate, and dust concentration.

Worm Conveyor for Removing Ash from Ash Hoppers. G. A. Chilaev. *Energetik* 1958, **6** (Jan.) 9–10. (*In Russian.*)

Uniform moistening of fly ash during removal from the ash hoppers is effected at one station by worm feed conveyors which serve simultaneously two electrostatic precipitators and consist principally of two coupled screws of different diameters housed in a hermetically sealed casing. Conveyor output at 60 rpm is 20 t/h, using a 5 kw motor.

From *C.E.G.B. Digest* 1958, **10** (Apr. 26) 1030.

Heat Recovery Plant

Let Computers Pick Your Heat Exchangers. R. E. Githens. *Chem. Engng.* 1958, **65** (Mar. 10) 143–6.

The application of digital computers to the design of heat exchangers as practiced by Du Pont is described. The computer is able to provide data on heat load, temperature difference and correction for multi-pass flow, Re number and heat transfer coefficients and the required area. Based on allowable pressure drop, the number of passes and baffle pitch are computed. The computer arrives more rapidly at the optimum solution than is possible by manual calculation.

Manufacture of Heat Exchangers. P. K. Richards. *Nucl. Pwr.* 1958, **3** (May) 213–4.

The preparation of the plates, their welding, and the stress relieving program are described in detail. The fabrication of tube nests, their cleaning and packing in polythene bags before shipment to the site, their installation in the shell on the site, and the welding of the joints between the tubes and thermal sleeves are indicated briefly.

Protective Coating of Metallic Surfaces. A. Huet. *British Patent* 792, 849 France, 2nd December, 1954.

The surface of metallic heat exchangers, especially air preheaters, is protected against attack by sulphuric acid by spraying small glass spheres in a steam of molten metal on to the surface so that a thin ($^1/_{10}$ to $^1/_{100}$ mm) continuous covering of glass is obtained. The bonding metal may be chromium, copper, lead, or aluminum, depending on the temperature of the gas.

Power Generation and Power Plant

Philo 6 completes Year's Operation. T. T. Frankenberg, A. G. Lloyd and E. B. Morris. *Elect. World*, 1958, **149** (Mar. 31) 41–5, 94.

Although the unit first started operation on the 20th March, 1957, it was frequently shut down and most of the time was devoted to test runs and to carrying out modifications. Trouble was encountered by high frequency vibrations and erosion in various valves which had to be redesigned, high initial iron oxide concentrations in the feedwater requiring increased filter capacity and eroding of babbitt and steel shells of the high pressure turbine bearings. Boiler efficiency has been 89.44% and the net plant heat rate 8,954 Btu/kwh, both very close to the design values.

Coal Comes Back to Savannah. Anon. *Coal Utilization* 1958, **12** (Mar.) 20–1.

The first unit for Port Wentworth Power Station consists of a C.E. boiler rated at 375 klb/h at 1560 psi and 1005/1005 F and a 40 MW turbogenerator. It is the smallest reheat unit designed so far and will have a net heat rate of 10,000 Btu/kwh. The decision to use coal as a fuel was based on the fact that the annual cost of coal would be cheaper by $500,000 than oil or natural gas. The station is to be extended later to 450 or 500 MW and the greater part of the coal handling plant is already designed for this ultimate size.

Instruments and Controls

The Ultrasonic Testing of Materials. H. Trommler. *Energie u. Technik* 1958, **10** (Mar.) 73–81. (*In German.*)

The various methods available for testing materials by ultrasonics are explained. Apparatus developed in Germany, their working principle and their range of application are described. Possibilities of further developments are discussed.

Power Reactor Instrumentation. R. J. Smith. *Nucl. Engng.* 1958, **3** (Apr.) 155–7.

The instrumentation required for a nuclear power station is discussed. A diagram is presented, showing the location of the various measuring points, and a schedule of central control room instrumentation is provided. This is subdivided into controls for the reactor, coolant circuits, steam raising units, turbines, dump condenser and feed system, alternators and transformers, emergency supply, station and unit transformers.

Shandon "Glowing" Smoke Density Indicator. Anon. *Heating* 1958, **20** (Apr.) 130.

The indicator developed by the Fuel Research Station consists of a glowing element placed in the side flue, its brightness being so adjusted that it is obscured when the smoke density corresponds to Ringelmann No. 2 shade. The element is viewed through an observation window in the front wall, and neither mirror nor glasses are required.

The Infra-red Spectrometer and Its Application. Anon. *B.C.U.R.A. Quarterly Gaz.* 1957, No. 33, 16–18.

The spectrometer contains a radiation source, a dispersing prism, and a thermal detector. The range of wave lengths of 2–15 μ is particularly suitable for obtaining an indication of changes in molecular structure of substances containing atoms joined by chemical bonds. The application of this method to gases, liquids, and solids, especially coals, is indicated.

The Accurate Measurement of Temperature. J. A. Hall. *Research* 1958, **11** (Apr.) 147–51.

The temperature range and accuracy of measurement of platinum resistance and mercury thermometers, thermocouples, and disappearing filament pyrometers are reviewed.

Valve Control Equipment on an Oil-fired Installation. C. W. Perry. *Fluid Handling* 1958 (Mar.) 60–2.

The system for controlling oil valves, steam valves, dampers, and igniters on the boilers of Littlebrook Power Station converted to oil firing is described.

Automatic Unit for Determination of Volatile Matter in Coal, Coke, and Char. R. P. Hensel and S. A. Jones. *Anal. Chem.* 1958, **30** (Mar.) 402–4.

A completely automatic timer apparatus for use with vertical tube furnaces has been developed which holds the crucible at the top of the furnace for a specified time and then lowers it into the furnace at a predetermined rate. The second timer holds the crucible in the furnace for a preset time and then actuates the mechanism for the return of the crucible to the top of the furnace. The unit is designed for two furnaces so that duplicate measurements can be made.

Nuclear Energy

Nuclear Power Developments. Anon. *Elec. Rev.* 1958, **162** (Mar. 28) 588.

In a lecture to the Royal Society of Arts, Sir Christopher Hinton stated that the cost of electricity generated by the first two power stations of the C.E.G.B. would be 0.66d. kwh. These costs would be reduced in later stations where higher temperatures were reached. This involved the provision of new steels, improved layouts, application of higher steam pressures, and new fuel elements probably of the ceramic fuel type.

Nuclear Energy Conference. Anon. *Elect. Rev.* 1958, **162** (Apr. 18) 743–8.

Abstracts of papers presented to the Federation of British Industries Conference on nuclear power are given under the headings: (1) Impact upon industry; (2) World's fuel resources; (3) Financial and investment aspects; (4) Size of U. K. program; (5) Types of reactors; (6) Radioisotopes; (7) New materials for nuclear engineering; (8) Reactor instrumentation; (9) Processing of fuel elements.

American Nuclear Engineering Conference. Anon. *Engineer* 1958, **205** (Apr. 25) 635–7; (May 2) 675–7; (May 9) 713–5.

The first part deals with developments in the private American atomic energy industry (investment, gross receipts and employment) and private reactors and reactor components, their operation and products. The following two parts describe exhibits by various industrial firms.

Grinding, Screening and Filtering

Pulverizing Coals. T. G. Callcott. *Proc. Australian Min. Metall.* 1957, **183** (Sept.) 43–76.

Brief descriptions of several types of unit pulverizer are given and the functioning of the components that crush, carry, dry and classify the coal is considered. A distinction is drawn between pulverizers which crush particle beds and those operating by free-crushing. The overall performance of pulverizers is considered in terms of correlations between mill variables, coal grindability, abrasiveness, moisture and particle size. The influence of pulverized fuel quality on boiler operation and pulverizing costs are described.

From *Fuel Abstracts* 1958, **23** (Apr.) 3035.

Analysis and Testing, Research

A New Dynamic Test Facility for Aqueous Corrosion Studies. S. Greenberg, J. E. Draley and W. E. Ruther. *Corrosion* 1958, **14** (Apr.) 45–6.

A dynamic aqueous recirculating corrosion test loop for a maximum temperature of 360 C, a maximum pressure of 3000 psi, and a flow velocity of 20–30 ft sec is described, which is intended for assessing the suitability of materials for water cooled reactors and the variables affecting corrosion. The four sampling sections can be replaced during operation, thus greatly reducing shutdown time.

Method for the Determination of the Ash Content of Coal. Coal Industry (Patents) Ltd., G. J. Pitt and R. R. Gordon. *British Patent* 793,301, 1st April, 1954.

In the determination of the ash content of coal by X-rays the degree of absorption of the beam and the intensity of fluorescent radiation emitted by iron are combined into a single signal which is proportional to the ash content corrected for iron.

The Direct Determination of Mineral Matter in Coal. M. Bishop and D. L. Ward. *Fuel* 1958, **37** (Apr.) 191–200.

Minor modifications to the method developed by Radmacher and Mohrhauer are described. The duplication of the results has been satisfactory and good agreement with the King-Maries-Crossley formula has been obtained.

Determination of Ferrous Iron in Pulverized Fuel Ash and Slags from Pulverized Fuel-fired Boilers. *J. Appl. Chem.* 1957, **7** (Nov.) 605–610.

The method of Wilson for the determination of the total ferrous content of silicate rocks has been modified so that it could be applied conveniently to samples as small as 50 mg. The ferrous content could be determined with an error which in 19 cases out of 20 probably did not exceed ± 30 μg of FeO. A study was made of the state of oxidation of the iron in p.f. ash and corresponding boiler furnace slags; the dependence of the ferrous content on the total iron and carbon contents of the ash was demonstrated. The total iron content and the ferrous ferric ratio were shown to increase with terminal velocity (free falling speed in air) of p.f. ash particles; the behaviour of the ferrous and ferric compounds in magnetic concentration of the iron in p.f. ash was also studied.

From *Fuel Abstracts* 1958, **23** (Apr.) 3700.

Solubility of Sodium Chloride in Superheated Steam. Z. V. Deeva and A. A. Kot. *Elekt. Stantsii* 1958, **29** (Jan.) 14–16. (*In Russian.*)

Investigations show that on raising steam pressure from 100 to 300 atm gage (at 550 C) the solubility of NaCl in superheated steam increased from 2 to 160 mg kg. Data on the solubility of NaCl in superheated steam compiled by the Union Heat Engineering Institute and the Power Institute of the Soviet Science Academy (by the latter from 140 to 300 atm gage), at 500 C lie on a logarithmic straight line and obey the formulas log C = 3.8 log p − 7.22 or $C = 10x^{7.22}p^{3.8}$.

From *C.E.G.B. Digest* 1958, **10** (Apr. 12) 922.

Non-destructive Testing for Nuclear Plants. F. S. Dickinson and E. J. Keefe. *Nucl. Pwr.* 1958, **3** (May) 224–6.

The inspection of welds in plants for highly radioactive processes by X ray or gamma ray, combined with penetrameter sensitivity tests, is described. For pipes of less than 3 in. wall thickness the double wall double image technique and for pipes of greater thickness the double wall single image method are prescribed.

From Coal to Coke. R. R. Cheradame. *B.C.U.R.A. Quartly Gaz.* 1957, No. 33, 1–12.

The Sixth Coal Science Lecture, in which the research carried out by CERCHAR was reviewed, and the results achieved in obtaining metallurgical coke from weakly caking coals were described. Details discussed in particular concerned: (1) Fissuring in carbonization of a single coal; (2) Blends of two fusible coals; (3) The part played by inert constituents; (4) Addition of nonfusible coals; (5) Coking plant at Marienau.

Economics and Statistics

Industrial Power of the Future. Anon. *Electricity* 1958, **11** (Apr.) 151–3.

Brief abstracts are given of Sir Christopher Hinton's Trueman Wood Lecture to the Royal Society of Arts. While Calder Hall was built to produce plutonium as a main product and electricity as a by product, the reverse is true for the nuclear power stations now under construction. The plutonium produced in these latter stations could probably be used most efficiently in fast breeder reactors. The first nuclear power stations will not be able to produce electric power competitively with conventional stations, but those coming into use in 1962 will do so and, if developments continue as before, power produced in nuclear stations in 1982 will cost less than half that generated in conventional stations.

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(Continued on page 67)

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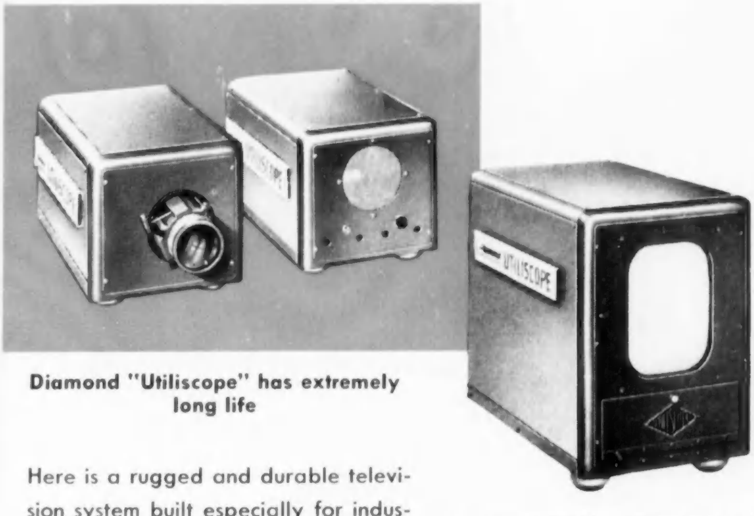

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